THE EAST AFRICAN AGRICULTURAL JOURNAL

Issued under the Authority of the East African Governors' Conference and published every other month
JANUARY, MARCH, MAY, JULY, SEPTEMBER, NOVEMBER

Subscription 5/- per annum, or 1/- per copy, post free, payable through any Agricultural Officer or to the Government Printer, P.O. Box 128, Nairobi, to whom all business communications should be addressed.

Editorial correspondence should be addressed to the Editor, Amani, via Tanga, Tanganyika Territory. Matter submitted for publication should preferably be sent through the local member of the Editorial Board.

EDITORIAL NOTES

Quality in Coffee.

The attention of all intelligent coffee-growers will have been closely held by the series of articles on fermentation contributed to the Monthly Bulletin of the Coffee Board of Kenya by Dr. Martin Case. In present circumstances of low demand and consequent greater selectivity on the part of buyers, the problems of quality have maximum importance. On the London market only the best coffee appears to be in demand at all.

Fermentation being the most readily available method of scouring coffee, and seeing that about the only point on which investigators agree is that deterioration may result from fermentation gone wrong, the subject is well worth attention even for that limited reason. Then there is the further question whether the process, or some particular form of it, can be used to improve, or at least develop, the quality of the bean. Opinion on this question is fairly evenly divided, with an increasing tendency, perhaps, to an answer in the negative.

The reason for the diversity is not far to seek. It is due to the absence of any reliable measure of the results obtained in experimentation. The difficulty is fully admitted by Dr. Case, who had to consider, as others before him, whether any means exists of obtaining evidence with some degree of reliability in its favour. The method of the multiplication of experts is dismissed, since it is the experience of all who have tried it that it merely increases confusion. Even a panel of two or three produces most discordant results, and the opinion of a Nairobi expert can be hopelessly at variance with that of his opposite number in London. In these circumstances it was decided to test the testers; a graded series of samples

was prepared, and a liquorer was eventually selected who produced an order of preference in close accord with the degrees of treatment given. Evidently a good judge, though we still do not know what he is judging.

This method is probably the best that could be devised for the evaluation of the results of local experiments. It provides a foothold, though not a very firm one, where all else is shifting sand. It will enable a decision to be reached in matters of local practice, though it is too much to expect that when the results are marketed the usual discrepancies will not appear.

When the effect of a definite process, capable of exact experimental application, is so much in doubt, it is not surprising that the operation of such other factors as climate, soil, age and heredity is hardly more than vaguely suspected. The standard of quality for a given locality may be reduced by unfavourable seasons, or the remission of cultural control, where these influences affect the normal development of the bean, but it cannot be assumed, as there is some tendency to do, that the most favourable conditions and the highest standard of cultivation will produce the best quality. In that case, it should be easy to show that quality is correlated with yield and this, so far as we know, has never been suggested. Rather the reverse: it is held in Costa Rica, for example, that as between high altitudes and low, the marked reduction in yield on the high estates is about balanced by the improvement in quality which accompanies it.

We are intimately acquainted with an ex-German estate in Usambara which ran wild during and for many years after the War. When it was first taken in hand the crop was among the highest priced in East Africa. The reshaping of the trees and some attempt at cultivation has been accompanied by a steady fall in the relative value of the produce, which is now quite undistinguished.

A more plausible suggestion is that coffee borne on young trees or new stems is superior to the crop from the same trees at more mature ages. This is held to account for the high prices obtained in new districts, as illustrated recently in the Southern Highlands of Tanganyika. A further idea that this is due to a soil factor appears to be negatived by the alleged fact that the crop of stumped trees regains its quality.

The test of quality which ultimately interests the producer is the relative price obtained. This introduces further confusion. From 1932 onwards, a scheme has been in operation whereby series of samples, selected with the co-operation of the Departments of Agriculture to represent the whole range of East African production, have been submitted by the Amani Research Station through the Imperial Institute to a well-known London firm for estimation according to a numerical scale of quality. So far as possible, the marking has been compared with the prices realized, and as yet there is surprisingly little relationship shown. If a correlation exists it must be revealed statistically in time, but present indicatons are that the issue is so confused that the time will be a long one.

- - - -

The Reproduction of Sisal.

The universal practice on sisal estates is to use as planting material either suckers, which are offsets from near the base of the stem of the parent plant, or

bulbils, which are small plantlets, with a more or less bulbous base, produced in large numbers from the flowering poles after the flowers have fallen. The bulbils themselves fall in due course, and are then ready to commence a separate existence. The sisal plant, like many other Agaves, has almost abandoned the production of seed. From the millions of "poles" developed on coastal estates, it is extremely rare to hear of even a single seed-capsule being observed.

On estates at a much higher elevation, such as exist in Kenya, if the developing pole is severed, a cluster of flowering branches is produced from the stump, and under these special circumstances appreciable quantities of seed are produced. These are of considerable interest to the plant-breeder but are of no direct use to the planter. The seedling progeny is exceedingly diverse, and none has been found in the many thousands raised which reproduces the combination of characters of the parent plant.

These elementary facts are here reviewed because reports and inquiries recently received reveal the existence, in responsible quarters, of misapprehension on the subject. We learn that it is seriously feared that the presence alongside ordinary sisal of the blue sisal, *Agave amaniensis*, which is now being distributed to estates, will affect the bulbil progeny of the former, so that it will no longer breed true. The fallacy of this idea is obvious to anyone with even a little knowledge of botany, but to others it may be explained that the bulbils, although they succeed the flowers, do not develop from them. The flowers are completely shed, ovaries and all, and the bulbils, which take the place of fruit and seed, are developed vegetatively, i.e. without any form of sexual fertilization. They are, in fact, produced by a process of budding, and their use for reproduction is in essentials analogous with the propagation of rose bushes or citrus trees from buds.

This, of course, is not to say that no variation can occur amongst bulbils. It is well known that notable differences are found, for example, in respect of the degree to which spiny leaf edges are developed. Liability to such variation is inherent in the plant itself, and cannot possibly be influenced by its neighbours.

\- - - -

Annual Report of the Department of Agriculture, Uganda.

We have received Part I of the Annual Report of the Department of Agriculture of the Uganda Protectorate for 1934, reviewing the position of agriculture and the progress of agricultural administration. Part II, dealing with experimental work, will be issued later.

Although weather conditions were on the whole unfavourable, there was a net increase over 1933 in the value of exports to the amount of £309,156. The large increase of the cotton crop made in 1933 was not quite maintained, but the value of the 1934 crop was considerably more, and the grade is described as probably the highest ever obtained. Cotton made a direct contribution to revenue, through the export tax of 2 cents of a shilling per pound of lint, of £111,106.

A special officer has been appointed for five years to work on the problem of controlling pink bollworm.

The zoning legislation controlling the handling of the cotton crop has worked successfully, resulting in more orderly marketing, reduction of uneconomic transport, and great improvements in the grade of seed cotton. A new Ordinance has made "touting" on behalf of cotton buyers illegal.

The exports of raw coffee totalled 154,298 cwt., valued at £293,313, an increase of 53,854 cwt. and £82,675 over 1933. The area of native-grown Arabica was increased by some 2,000 acres during the year. Strict control is exercised by the Department and the Native Administration, and in general a high standard of cultivation is maintained.

A rapid increase is taking place in the production of fire-cured tobacco.

The two sugar estates in Uganda produced between them 21,497 tons of refined sugar, which is substantially more than is consumed annually in Uganda, Kenya and Tanganyika. Export possibilities are regarded as exceedingly remote, and the necessity is indicated of developing the local market by drastic retail price reductions.

There is another side to this picture of rapid expansion of production and revenue, and it applies not only to Uganda but to all the East African Protectorates. It is described in this Report, with reference to Buganda, by the Acting Senior Agricultural Officer in the following terms: —

> "The soil is still being neglected, and hardly any measures were taken by natives during the year to improve soil fertility or to prevent erosion. Simple measures such as the mulching of coffee, the planting of cotton in rows across the slopes, and the proper care of the plantain gardens are all forgotten during the urge to plant large areas which later become out of hand. The yield of cotton from the same area could, without additional effort, be doubled by mere attention to spacing, and likewise a small, properly managed coffee plot would produce more profit than a large neglected area. The soil erosion which has occurred on plots of established coffee is so serious that many plots have had to be abandoned as unproductive, and this ruination of cultivable land is becoming a serious menace."

The obvious lesson is that agricultural instruction must go hand in hand with production. Governments which find in the increased revenues from native-grown crops an apparently heaven-sent remedy for their financial difficulties must recognize that unless they are prepared to strengthen the field staff of agricultural departments to the extent necessary to meet their extended responsibilities their relief will have only a short duration. The movement must be one of genuine development—not exploitation of the capital resources of the soil.

The Fermentation of Coffee.

Just as can be demonstrated so often in other realms of human activity, it has happened in the circles engaged in coffee cultivation and the coffee trade that custom—to use no stronger word—holds sway over judgment; in these circumstances a new impetus becomes necessary for the progress of the industry.

At the present time a number of experts of the older generation are imitating the ostrich and hiding their heads in the sand so as not to see innovations. They are unwilling to concede that coffee prepared by the wet method without fermentation could possibly be as good as fermented coffees. But when one submits samples to them without any possibility of their knowing the method of preparation they are incapable of distinguishing those prepared by the wet method without fermentation; and they value at a higher figure sometimes the one and sometimes the other wet method product, with or without fermentation. This has already been demonstrated in practice. (Trans. from A. Reuter, *Agriculture et Elevage au Congo Belge*, 1935.)

Research Notes

THE PRODUCTION OF ALCOHOL FROM SISAL WASTE. (*Les Produits Coloniaux et le Material Colonial, No. 128, Institut Colonial, Marseille, 1935.*)

The utilization of sisal waste for the production of industrial alcohol has been the subject of frequent discussion. In East Africa the results of an investigation of the question by Mr. V. A. Beckley were published by the Kenya Department of Agriculture as Bulletin No. 6 of 1929. Mainly from consideration of the low and fluctuating sugar content of the juice, the conclusion was reached that, using the process then envisaged, the operation would not be profitable. One of the practical difficulties would be the necessity of adopting a system of decortication without added water, which in itself would be a drastic change from present practice.

According to an extract from a report by M. Louis Renoux, presented to the Conference de Motorisation Coloniale, December, 1934, and published under the above reference, a successful process is actually in operation at Diakandapé in the French Soudan. The method adopted differs in one important particular from those previously designed. For the preliminary sterilization of the juice, necessary to avoid the rapid destruction of the sugar by lactic and butyric fermentation, instead of the expensive heating usually proposed, a special antiseptic is used, which is claimed as totally suppressing bacterial activity while permitting full liberty of action to the specially trained yeasts employed. This convenient antiseptic is not described more specifically than by the statement that it consists partly of a chemical, partly of a vegetable product. Its use permits of the fermentation of the raw juice in open tanks.

The yeasts, of which some five or six species or strains are available, have been selected on the spot, and, as indicated above, have been trained by a long process of acclimatization to function in the presence of the bactericide.

The method of decortication is not described, but it is evidently carried out without addition of water. The pulp is passed through a press working on a system modified from that of a sugar-cane mill. The yield of juice is 60 to 65 tons per day from a factory treating 100 tons of leaf. According to the sugar content of the juice, which varies with the season from 35 to 50 grammes to the litre, the output of alcohol from these quantities is 1,200 to 1,800 litres. The yield per hectare usually varies between 200 and 325 litres.

W.N.

TUBA ROOT FROM TANGANYIKA.

The Director of the Imperial Institute has forwarded a report on two 10 lb. samples of Derris root grown at the Amani Research Station. The possession of a high rotenone content by these samples was confirmed. A commercial valuation states that material of equal quality would be readily saleable in the United Kingdom, and on to-day's market would be worth 8d. to 9d. per lb., c.i.f. London, for the finer and 7d. to 8d. for the coarser roots.

Experiments are being continued on a larger scale at Amani to determine the cost of production and the yield per acre.

Armillaria Root Rot in East Africa

ARMILLARIA MELLEA (Vahl.) Quél.

By G. B. WALLACE, *B.Sc., Ph.D. (Edin.), Mycologist, Tanganyika Territory.*

INTRODUCTION.

Armillaria root rot is known in all the East African colonies. While common as a saprophyte in forest soils, it is occasionally associated with disease of woody crops in epidemic proportions, and therefore merits recognition by planters. The disease is easily recognized and need not be confused with other root diseases. It has been known for many years in Europe, and for a shorter period in tropical countries. The story is far from complete, but a considerable body of literature has been produced on the subject. It is the object of this paper to discuss the subject generally, with particular reference to conditions in East Africa. Technicalities are avoided so far as possible, but a fairly wide view is required in order that control measures which really concern the planter may be intelligibly understood and applied.

Plantations are known in East Africa where the fungus, although abundant in the soil, does no harm to the crop. It also occurs as a parasite in isolated patches on other plantations, but yielding readily to control. There is also the extreme, where it is a cause for some alarm: in that case it is not the only factor concerned.

As the different aspects of the subject bear closely on one another, they cannot easily be considered under independent headings, but for practical purposes that is the only convenient method and will be followed.

Various names have been applied to this disease, e.g. "Split Root Disease" in Java, and "Collar Crack" in Nyasaland and elsewhere. In Tanganyika Territory it has been referred to as "Armillaria Root Rot".

DISTRIBUTION.

Armillaria mellea has not been recorded in the Western Tropics. The disease has been studied in cacao by Dade in Togoland and the West Coast. In that crop it is also known in Uganda and St. Thomas Island. In tea it has been studied in Ceylon, Java, Sumatra, Uganda, and Tanganyika. Its first record in Ceylon was by Gadd (7), who described it in nursery plants and subsequently on mature bushes of tea. In Java and Sumatra, Bernard (1) states that it occurs extensively in young plantations on fertile forest soils, but that as a rule the disease disappears of its own accord after six to eight years. It is also present in Australia and the Western States of America. There are extensive references to its occurrence in Europe.

Table I has been compiled to show the known host range and distribution of Armillaria in East Africa. Small (19), in 1923, stated that this root disease was far more common in Uganda plantations than any other, and that has since been the experience in Kenya, according to McDonald (14), and in Tanganyika Territory. Small indicates that this disease and Brown Root Rot would be more common than they are on Uganda coffee but for the fact that elephant grassland, rather than forest, has been used for planting.

Hansford (11) in 1929 described the disease in tea in Uganda. In Nyasaland Armillaria root rot in tea was recorded by Smee (15) in 1926. That author, Leach, Clements, and Butler have each since recorded additional hosts in Nyasaland in reports (3 and 15) of the Department of Agriculture from 1926 onwards; a list given in 1933 presumably includes

dead trees, and is therefore not included in Table I.

In Kenya, Armillaria has been discussed by McDonald (14) in coffee and other woody plants. In Tanganyika the present writer (23) has rendered popular accounts of the disease in various crops.

TABLE I.
HOST RANGE OF ARMILLARIA IN EAST AFRICA.

Acacia Cunninghamii	*T			
A. dealbata (Silver Wattle) ...	T			
A. decurrens (Black Wattle) ...	T			
Acacia sp. (indig.)	T			
Acrocarpus fraxinifolius ...	T			
Albizzia moluccana	T			
Bauhinia sp.				U
Cajanus cajan (Pigeon Pea) ...	T			N
Calodendron sp.	T			
Camellia Thea (Tea)	T	K	U	N
Casuarina sp.				N
Cedrela odorata	T			N
C. toona	T			N
Chlorophora excelsa ("Mvule") ...	T			
Cinchona sp. (Quinine)				N
Citrus aurantium (Orange) ...	T			
C. limonia (Lemon)	T			N
Coffea arabica (Arabian Coffee) ...	T	K	U	N
C. robusta (Robusta Coffee) ...			U	
Crotalaria sp.	T			
Cupressus lusitanica	T			
Cyphomandra betacea (Tree Tomato)	T			
Eucalyptus citriodora	T			
E. globulus	T			
Eucalyptus sp.				U
Erythrina lithosperma	T			
Erythrina sp.				U
Ficus sp. (Fig)				U
Grevillea robusta	T			
Hibiscus Rosa-sinensis	T			
Hibiscus sp.				U
Hevea sp. (Para Rubber) ...				U
Jacaranda sp.	T			
Mangifera indica (Mango) ...			U	N
Manihot Glaziovii (Ceara Rubber)				U
M. utilissima (Cassava)	T			
Musa sapientum (Banana) ...	T			
Olea europaea (Olive)				N
Poinciana regia (Flamboyante) ...				N
Psidium Guajava (Guava) ...				U
Rosa sp.	T			U
Saccharum officinarum (Sugar Cane)	T			
Sesbania sp.	T			
Spathodea sp.				U
Tephrosia candida				N
Theobroma cacao (Cacao) ...				U
Trema guineensis	T			
Widdringtonia whytei (Mlanje Cedar)	T			N

* The letters T, K, U, and N indicate that the plant has been recorded as a host of Armillaria in Tanganyika Territory, Kenya, Uganda, and Nyasaland respectively.

DESCRIPTION OF THE DISEASE.

The disease when observed in the field has usually reached a stage when the leaves are wilting and turning yellow and brown. By that time the roots and collar are already heavily infested, and it is only a matter of time till the leaves fall and only the bare skeleton is left (Fig. 1). It very often happens that one side of a tree is affected first, indicating that disease has started in the roots on that side.

Where one tree is found affected, one or more, even a dozen, of its neighbours may also be affected in various stages. In such cases contamination has arisen from one source or has spread from one tree to another. Unless checked, the disease may extend indefinitely in one or more directions.

Closer examination of an affected tree shows the characteristic symptom which has given rise to the name Collar Crack: in tea, coffee and other trees, cracks can be seen running up the stem for several inches, and in the root system even down to the smaller roots (Fig. 2). In Ceylon, according to Gadd (8), in a short clear account of the disease in tea, the fissures are rarely exhibited at the time the bush dies, but they usually develop as the bush dries out in the laboratory.

The cracks are indicated by brown or black lines of fungus tissue, which bulge out as a frill or crust (Fig. 3). There is usually more than one crack or frill on

the circumference of the collar, stem or root, but a section of the part shows an even greater number of cracks in the wood. The larger cracks are radial, but there are others branching and sometimes tangential. In the wood they are full of a white fungus mycelium which is in the form of layers.

Even if cracks have not yet appeared it is very often possible to diagnose an infected tree on exposing the root for some inches. Felt with a knife, the bark is found to be brittle. A further important symptom is the layers of white mycelium in the bark and between bark and wood. These layers are not so clearly feathery in appearance as in the fungus *Ustulina zonata*, which is also associated with disease of coffee, tea, and cacao, etc., in parts of East Africa.

FIG. 1.
Tea bush infected from stump on left.

According to Small (19), the mycelium has been found extending from the roots as far as the upper branches in a well-grown mango tree. In Tanganyika the sheets of white mycelium have been observed under the bark of *Trema guineensis* to a height of ten feet. Small states that affected roots are damp to the touch when freshly split open, and that is the usual experience.

The bark of trees infected with Armillaria has a characteristic and not unpleasant odour of mushrooms. Bark with Ustulina has not so clearly defined an odour.

A frequent characteristic of Armillaria is the presence of rhizomorphs. These are red-brown and finally black branching strands of fungus mycelium which extend from infected trees through the soil. They are 2-3 mm. in diameter, and tough or brittle. Growing freely in the soil, they are round in section; when lying on the bark they are flattened. They can be most easily distinguished from plant roots by their clean white core. Their appearance has given rise to the name "Bootlace Fungus" for Armillaria.

In Tanganyika and Uganda, rhizomorphs are usual. According to McDonald (13), on the other hand, they

are not definitely known to occur in Kenya. Butler (3) states that he found them on only one tea bush in Nyasaland. Leach (15) also states that in Nyasaland they are not found growing so abundantly as in temperate countries, except on pigeon peas. Absence of rhizomorphs has been noted in the Gold Coast (2, p. 20), although their formation was easily induced from infected cacao material in artificial culture.

A character of Armillaria-infected wood is the presence of black lines; these, however, are not diagnostic of this fungus alone, and can therefore be misleading.

The lower roots, especially of large trees which have been infected for some time, change to a homogeneous evil-smelling jelly. This is doubtless largely produced through the action of other decay organisms.

THE FRUCTIFICATION.

Armillaria has a sporophore or fructification of the toadstool type, which grows in small or large groups on dead wood or roots. They are common in temperate countries, but are rare in East Africa. Small (19), in 1923, stated that the Botanist of the Department of Agriculture found the fructifications on a Hevea tree in the Botanic Gardens at Entebbe, Uganda, and that they were definitely shown to be *A. mellea*. The second record in East Africa is from Nyasaland, where Butler (3) recorded, in his report on an investigation of the disease in 1928, that he found sporophores on an almost dead tea bush and round the base of a dead *Poinciana regia* tree bordering the tea. It remains to record that the sporophores have now been observed growing from dead forest roots in a tea plantation in Tanganyika Territory by the present writer in July, 1935 (Figs. 4, 5, 6).

In the latter case they were found in about two dozen groups on superficial dead forest stumps, on dead forest roots just below soil level, and growing out from the cut ends of roots, where they abutted on the sides of pits from which diseased tea bushes had been removed. (The latter occurrence showed that the instruction to follow up and remove old roots where pits are dug had not been carried out.) The presence of the sporophores in the pits was doubtless encouraged by the damp conditions which favour their formation. Considering the extensive acreage of the estate in question, the sporophores were relatively very scarce, and were only found as a result of two days' search.

The name *Armillaria mellea* has been used for the species associated with Collar Crack in Uganda, Kenya, Southern Rhodesia, and South Africa. The tropical form of Armillaria sporophore differs slightly from the forms of *A. mellea* found in Europe. Petch (17) considers that the forms found in Java and West Africa are the same as what he described (16) as *A. fuscipes* on *Acacia decurrens* in Ceylon in 1909. The latter species is said to differ from *A. mellea* in having fewer individuals in each clump of sporophores and in having narrower and darker stalks and paler caps. The Tanganyika material differs only slightly from Petch's *A. fuscipes* in having more sporophores in a group, smaller caps, and longer stalks. But unless systematists decide otherwise, the name *A. mellea* will be retained, for various practical reasons, for the Tanganyika material. The following is a description of the latter sporophores: —

The pileus or cap is up to 5.5 cm. wide, but more often about 3.5 cm.; it is 5 to 8 mm. thick at the centre, and thin at the margin; it is slightly convex; when mature it is slightly wavy or corrugated round the margin and rather sunken at the centre. In colour the cap is brown or

yellow-brown at the centre and fades to the outer half, where it is white or very pale yellow. When very young it is closely covered with very dark red-brown scales, but when older these are scattered round the centre. The margin of the cap is striate. The flesh is white.

The stalk is up to 13.5 cm. high, but varies as a rule between 5 and 8 cm. The base is swollen to almost twice the width at the apex. The average width at the centre is about 5 mm., and it is attenuated upwards. When young the colour is pale brown, but changes towards maturity to a dark brown. It is covered with grey scales. In section it is solid or slightly hollowed, and pale with a dark brown margin.

Clusters taken at random numbered 5, 5, 6, 6, 7, 14, 14, 15, and 27 individual sporophores. They arise from a close cushion-like mass of fungus mycelium at the surface of the substratum.

No ring is seen at the base, and only the vestige of a ring near the apex of the stalk in these specimens. The gills under the cap are white, fairly close, thin, slightly decurrent, and 2 to 4 mm. broad.

The spores are white, oval and smooth; the dimensions of 25 spores are 6.3 to 9.2 x 4.5 to 6.4 microns, averaging 7.4 x 5.1 microns.

PARASITISM OF ARMILLARIA.

The fungus *Armillaria mellea* is, as stated above, a common soil saprophyte.

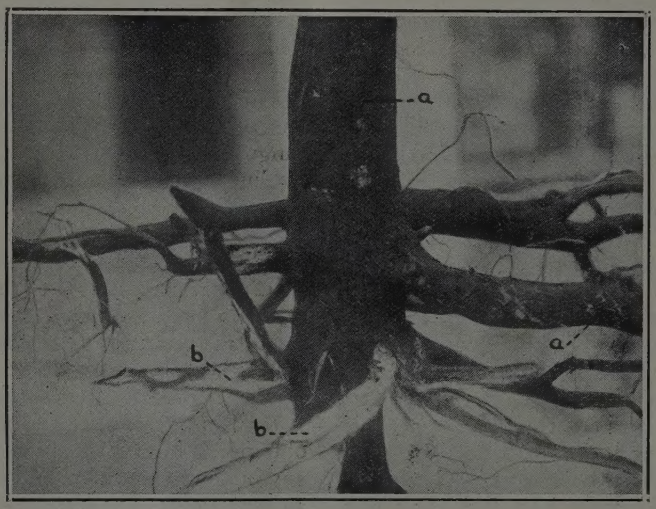


FIG. 2.
Dead tea root showing cracks (a) three opened to show mycelial sheets (b).

When it becomes established in a dead tree it increases considerably in quantity, and, whether or not it increases in virulence, at least it develops increased capacity for infection through its greater concentrated mass of mycelium and rhizomorphs.

It develops its best growth in an acid medium, such as in the soils required by tea, but it can be found in quantity in the less acid soils, such as on Kilimanjaro. Reitsma (18) obtained best growth

on artificial media at 25° C. and at an acidity of pH5.

Armillaria is certainly not to be classed with the intensely parasitic fungi, such as the obligate parasites—rusts, smuts, etc.—but it quickly takes advantage of any weakened resistance in living hosts.

Close on two hundred host plants of Armillaria have been recorded in the literature. Between forty and fifty are known in East Africa (Table I), some of these not being recorded elsewhere. Unfortunately they include some of our major crop plants, and several useful shade, shelter and ornamental trees, and also some native food crops.

Even as a saprophyte Armillaria does not attack all species of trees with equal readiness; this is a matter of considerable importance in the question of control, and will be dealt with below.

RESISTANCE AND SUSCEPTIBILITY.

The conditions which are liable to reduce the resistance of a potential host plant may be environmental, such as poor or denuded soil, or biological, such as the presence of other parasites. Various authors have referred to the dependence of Armillaria for part of its parasitic activity on such factors.

Day (5) showed in 1927 that *A. mellea* could enter the tree through uninjured living bark, but that there was very good evidence for believing that even when this takes place it acts as a secondary and not as a primary cause of disease. In 1933 (*in lit.*), he stated that he had found *A. mellea* following after *Phytophthora cambivora*, the cause of the root-rot of sweet chestnut (and beech), commonly known as the Ink Disease of chestnut.

Day (6) also, in 1929, made the statement that he was led to consider that, although a proved parasite, the fungus could only establish itself successfully in a tree and kill it when other, less obvious, causes such as drought, defoliation or human interference with natural conditions had brought about a weakening of the host and thus lessened its resistance. According to Briton-Jones (2), "throughout the very extensive literature on *Armillaria mellea*, the parasitic activities of the fungus are regularly correlated with excessive soil moisture". This was the experience of Butler (3) in Nyasaland. It must therefore be kept in mind as a possibility elsewhere in East Africa, although it must be stated that in the experience of the present writer the disease has not been associated with excessive moisture. The latter must be considered as one of the many factors which reduce resistance of the plant, though in addition it favours the activity of the fungus itself.

Guyot (9) found severe dieback of young elms in the west of France associated with the combined action of *A. mellea* and insects. In the same district pines are simultaneously attacked by *A. mellea* and termites. He cites analogous cases from contemporary literature.

Small (19) regards Armillaria as a wound parasite.

In Tanganyika no evidence has been obtained of the simultaneous action of any other parasite along with Armillaria, but an outstanding case of severe disease is associated with the presence of many old stumps together with a loss of much surface soil on steep slopes, and a practice in the past of clean weeding. That had resulted in weakening the resistance of the crop, which is now heavily infested with Armillaria.

The susceptibility of the species of host is important. For example, observations indicate that coffee is much less susceptible than tea.

In the *Review of Applied Mycology* the work of Hendrickson (12) in California is referred to as follows: "Of the root stocks used for stone fruits at the

present time in California the Myrobalan appears to be the most resistant. The French pear (*Pyrus communis*), the Northern Black Walnut (*Juglans hindsii*) and the fig (*Ficus carica*) are the only deciduous orchard trees whose resistance has been definitely established. Apples, especially if grown on Delicious stocks, are also considered to be resistant."

As regards the possibility of strains of the fungus, Childs and Zeller (4), in 1929, stated that their observations in the Pacific Coast States indicate the presence of two distinct strains of *A. mellea*, one inhabiting the roots of conifers, especially Douglas fir (*Pseudotsuga taxifolia*), and the other being prevalent in oak-cleared land.

The occurrence of strains of Armillaria was suggested by the present writer (23) to account for heavy infection of Grevillea trees growing among coffee bushes which were all free from the disease, but which are susceptible on other plantations where Grevillea is healthy.

Thomas (20), in 1929, found that the invasion of roots is effected by the direct penetration of a branch of the parent rhizomorph through the healthy cork layer of the host, irrespective of the resistance or susceptibility of the latter. In susceptible roots he found that the rhizomorph makes rapid growth and causes general destruction of the host tissue, while in resistant ones the fungus, though readily gaining admission, is unable to establish itself. Such roots are only slightly attacked, and any wounds thus formed are quickly healed. There appears to be little correlation between structural or morphological host differences and resistance to *A. mellea*, which seems to be in the nature of a vital antagonistic interaction between host and parasite.

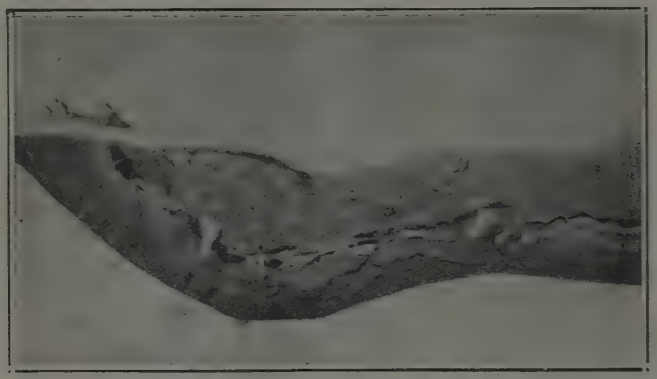


FIG. 3.
Dead tea root showing frill of mycelium along the crack.

METHOD OF SPREAD.

Susceptible plantation crops can doubtless become infected directly from Armillaria present in the soil, but that method is probably uncommon. Of greater importance is infection from the fungus accumulated in roots of dead trees and stumps left in the ground after clearing operations. Dead plantation trees themselves also become a source of infection to their neighbours.

Spread of the fungus to the roots of a crop can take place either by direct contact of infected roots with the living roots, or by means of the rhizomorphs

which radiate out from the former. Hundreds of infected coffee and tea roots have been examined in Tanganyika, and without exception infection has taken place from diseased roots lying against or in fairly close proximity to the dead bush. It is doubted whether rhizomorphs have an effective range of more than a few feet, but this requires confirmation.

There is no evidence that the spores in the fructifications of Armillaria are of importance in spreading the fungus, particularly where, as in East Africa, the fructifications are so very rare.

CONTROL.

Where the disease occurs in isolated trees or groups of trees, it is possible to apply the well-known methods of control, e.g. removing all dead and infective material from their neighbourhood.

There is, however, the other extreme, where a large acreage is affected. In that case, no one routine can be applied economically to the entire area; it becomes necessary to deal with groups of trees or single fields according to the circumstances, such as degree of infestation, presence of dead stumps, slope of the land and other factors affecting the health of the crop, cost of the operations, ultimate possibility of effecting control, and the results to be derived.

In the following paragraphs the subject of control is discussed rather than dogmatized, and the planter is advised to adopt suggestions which apply to his particular case.

An example of straightforward effective control is the case of a coffee plantation in the south of Tanganyika: a number of isolated coffee trees and groups of up to six had been infected with Armillaria from roots of the original savanna trees left in the ground. Stumps had been cleared, but odd roots remained. Each diseased coffee tree was dealt with in turn; the soil was dug away and the roots completely exposed. These and the contaminating roots and rhizomorphs were removed, dried and burned along with all the small pieces of roots and wood, so that no visible means of future infection remained. In addition, where groups of affected trees were removed, a trench was dug, 3 ft. deep and over 1 ft. wide, to isolate each group, including neighbouring, apparently sound, trees, the soil being thrown to the inner side. Care was taken that, so far as possible, no partially infected coffee trees remained standing. In the following planting season the soil was re-examined for chips and roots, as it was replaced in the pits, and then the ground was replanted. Further cases of infection will be similarly dealt with. The method promises to be perfectly successful, while the cost is relatively small. Had lime been available it would have been mixed with the excavated soil to hasten the decay of small pieces of wood which might have been overlooked.

An example of the problem on a larger scale, in which all the difficulties are not yet overcome is as follows: The estate is planted with tea on sloping land. The removal of all stumps before planting was undertaken only on a limited area, but that area is still almost free from Armillaria. In parts of the estate complete eradication of stumps would have been a physical impossibility without great expense and excessive disturbance and loss of soil; such fields are now heavily infested. In parts many tea bushes are diseased or dead, and many susceptible stumps remain. The difficulty and expense of removing these stumps, and the impossibility of ensuring freedom from the disease in future plantings, suggests the advisability of abandoning the worst parts temporarily.

In less affected parts of this plantation dead tea is being eradicated and wide

pits excavated; the contaminative forest roots bordering the pits are followed up and removed so far as possible, and together with all scraps of wood are burned either in the pits or in the boles of old stumps.

Camphor stumps which are very large and buttressed are left untreated, as there is no evidence of their susceptibility; elsewhere two groups of camphor stumps twenty-five years old have been examined and found free from Armillaria.

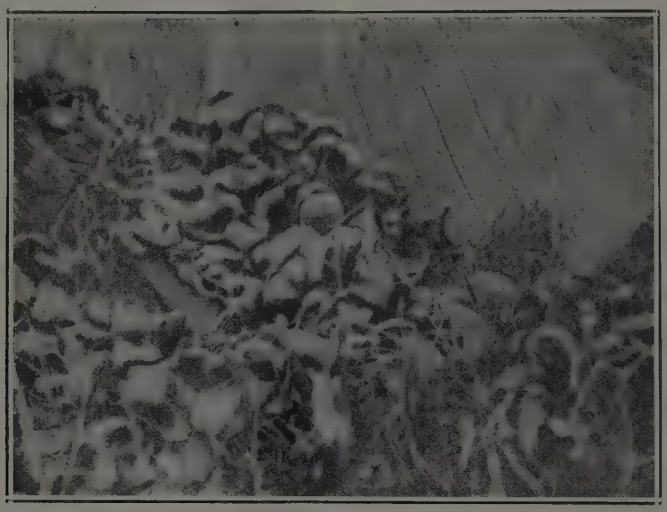


FIG. 4.
Clusters of Armillaria sporophores of various ages at the base of a dead forest stump.

The importance of forest stumps depends on their size, which will indicate the period they may take to decay or the difficulty or otherwise of removing them, and also on their susceptibility. With this in mind the identity of the forest trees on this estate was determined through the kindness of Mr. P. G. Greenway, Botanist at the East African Agricultural Research Station, Amani, and so far as possible their susceptibility was decided.

Among trees which are apt to start disease in Nyasaland (3) are *Afrormosia angolensis* and *Parinarium mobola.*

In Tanganyika, the forest tree *Trema guineensis* is very susceptible, but small, and can be easily removed, while there are giant trees, such as *Piptadenia Buchanani,* which are very susceptible but for practical purposes impossible to remove. In such cases it is recommended that the soil be cleared away from the stump and buttresses as deeply as possible, to facilitate their more rapid decay by drying and by the action of wood-rotting beetles, termites, fungi, bacteria and other organisms, and in the meantime that the crop should not be grown in their immediate neighbourhood.

It is doubtful to what depth in the soil Armillaria can live, but since it cannot live without free oxygen (18) it may not penetrate deeply. On the other hand, the fungus has been found as mycelial plates and rhizomorphs within and in the immediate neighbourhood of roots of

the forest tree *Piptadenia Buchanani* to a depth of five-and-a-half feet. Butler (3) states that in the well-aerated Mlanje soils in Nyasaland they go down at least to two-and-a-half feet.

It is important that what measures are decided upon be undertaken thoroughly, otherwise expense and disappointment will result. A common mistake when digging pits for the removal of dead plants is to dig them too small and to allow the contaminative forest root or roots to remain; that is inviting infection in future plantings. After proper treatment it should be safe to replant in six months' time.

When trees have been rendered susceptible through loss of surface soil, the land may be brought back into good condition only with very great difficulty, e.g. by terracing, drainage channels, cover-cropping, or application of organic or artificial manures. Stumping, terracing, and drainage, etc., should of course be considered before planting is commenced at all; one occasionally sees the difficulty and futility of attempting these too late.

As regards preventive as distinct from remedial measures, the possibilities and limitations will have been inferred from what has already been said above, and need not be repeated.

There follow a few references to direct methods of attack on Armillaria, which might, under certain circumstances, be applicable in East Africa, such as when a few valuable trees are diseased.

Thomas and Raphael (21) recommended that in already affected orchards the less affected trees should have their roots uncovered in summer and left exposed to the action of sunlight; also that two or three applications of iron sulphate (one pound in four gallons of water) may be given at intervals of three or four weeks. Permanganate of potash (half an ounce in four gallons of water) has also proved successful in checking the development of the fungus.

Guyot (10) in collaboration with Hias obtained encouraging results in the control of *A. mellea* on pines in France by exposing the roots and painting them with an iodine solution (0.5 per cent).

Reitsma (18) in Holland states that soil disinfection tests indicated that the best control of *A. mellea* is effected by 0.6 per cent Uspulun or corrosive sublimate (20 litres per square metre), carbon disulphide (100 gm. per sq. metre), or 10 per cent copper sulphate with an admixture of calcium oxide.

Voglino (22) states that in 1920 five mulberry trees showing the initial symptoms of root rot were treated by digging a trench one metre in radius round the collar and mixing into the soil from three to five kilograms of calcium cyanamide, according to the size of the tree. He records that by 1926 the disease appeared to have been arrested, and later the trees resumed perfectly normal growth, in contrast to some adjacent untreated trees which were quite withered.

According to Weindling (24), a parasitic fungus in *Armillaria mellea* is *Trichoderma lignorum*; whether this has possibilities for control is doubtful.

It is not intended to infer that the chemical treatments recorded above have immediate practical application in our plantations, but they are suggestive, and it is not unreasonable to hope that they may lead to useful subsidiary methods of attack in the future.

I have pleasure in acknowledging the hearty co-operation of various planters in the study of the problem described in this article. I also gladly acknowledge the facilities placed at my disposal by the Director for study in the library of the East African Agricultural Research Station, Amani.

FIG. 5.
Cluster of sporophores half natural size. The gills can be seen at right.

LITERATURE.

(1) Bernard, C.—Meded. Proefst. voor Thee 83, 27 pp., 1923. (R.A.M. III, 1924, p. 64.)

(2) Briton-Jones, H. R.—The Diseases and Curing of Cacao: Macmillan and Co., Ltd., London; 1934.

(3) Butler, E. J.—Report on Some Diseases of Tea and Tobacco; Zomba, Nyasaland, July, 1928, 30 pp., 12 figs.

(4) Childs, L., and Zeller, S. M.—Phytop. XIX, 9, pp. 869-873, 1 fig., 1 plan, 1929.

(5) Day, W. R.—Quart. Journ. Forestry XXI, pp. 9-21, 1927.

(6) Day, W. R.—Forestry III, 2, pp. 94-103, 1929.

(7) Gadd, C. H.—Rept. of the Myct. Tea Res. Inst., Ceylon, Bull. 2 (Ann. Rpt. for 1927), pp. 7-18, 1 pl., 1928.

(8) Gadd, C. H.—The Tea Quarterly III, Pt. 4, pls. I and II, pp. 109-113, 1930.

(9) Guyot, R.—Compte Rendu 52e Session Assoc. Franç. pour l'Avancement des Sciences, La Rochelle, pp. 391-393, 1928. (R.A.M. IX, p. 279, 1930.)

(10) Guyot, R.—Rev. Gén. des Sciences XLIV, 8, pp. 239-247, 6 figs., 1933. (R.A.M. XII, p. 799, 1933.)

(11) Hansford, C. G.—Ann. Rept. Dept. Agr. Uganda, 1928, pp. 46-47.

(12) Hendrickson, A. H.—Calif. Agric. Exp. Stn. Circ. 289, 13 pp., 7 figs., 1925. (R.A.M. V, p. 37, 1926.)

(13) McDonald, J.—Dept. Agric. Kenya, Bull. 21, 1928.

(14) McDonald, J.—Dept. Agric. Kenya, Mycol. Leaflet No. 8.

(15) Nyasaland Dept. Agric. Ann. Rpts., 1926 to 1933.

(16) Petch, T.—Ann. Roy. Bot. Gdns., Peradeniya, Ceylon, IV, p. 299, 1909.

(17) Petch, T.—Trans. Brit. Myc. Soc. XIII, pp. 238-253, 1928.

(18) Reitsma, J.—Phytop. Zeitschr. IV, 5, pp. 461-522, 8 figs., 3 diags., 1932. (R.A.M. 11, p. 681, 1932.)

(19) Small, W.—Dept. Agric. Uganda, Circ. No. 9, 1923.

(20) Thomas, H. E.—Abs. in Phytop. XIX, 12, pp. 1140-1141, 1929.

(21) Thomas, P. H., and Raphael, T. D.—Tasm. Journ. Agric., N.S. VI, pp. 1-6, 4 figs., 1935.

(22) Voglino, P.—La Difesa delle Piante VI, 5, pp. 1-2, 1929. (R.A.M. IX, p. 213, 1930.)

(23) Wallace, G. B.—Dept. Agric. Tang. Terr., Mycol. Leaflets 6 and 16.

(24) Weindling, R.—Phytop. XXIV, 11, pp. 1053-1179, 1934.

Types of Robusta Coffee and their selection in Uganda

By A. S. THOMAS, *Assistant Botanist, Uganda.*

There are few species of plants which have received so many scientific names as have been bestowed on Robusta coffee. It has been shown by Chevalier that the correct name for this group of coffees should be *Coffea canephora* Pierre, which was the name under which the species was first described; all the other names applied for forms of this coffee—*C. robusta, C. Laurentii, C. arabica* var. *Stuhlmanii, C. bukobensis, C. Maclaudi, C. ugandae*—refer to varieties of the species. Not only do the forms differ on account of genetical reasons—a group of wild coffee in the forests usually comprises many different types—but also the appearance of any one type will vary greatly according to environment: a plant which in the forest is tall, with large flat leaves and few flowers, when grown in the open may be stunted, with small furrowed leaves and many flowers; even on a single tree there may be great differences between the small, narrow leaves at the top of the tree in the light and the large broad leaves in the shade below.

In many of the forests of Uganda this coffee occurs wild, sometimes in such abundance as to be the dominant plant in the undergrowth. The plant has been cultivated by the natives for some considerable time. Speke, in writing of his arrival at Masaka in 1861, mentions the coffee: "This grows in great profusion all over the land in large bushy trees, the berries sticking on the branches like clusters of holly berries." The coffee was not used by the natives as a beverage, but for chewing, for which purpose the cherries are picked before they are ripe, boiled, and dried.

In some places the native coffee industry was quite important; for example, on the Sese Islands in Lake Victoria, whence considerable quantities were exported to the mainland.

When coffee-planting by Europeans was commenced in Uganda, at first only Arabica coffee was planted; but about 1910 seed of Robusta coffee was introduced from Java, and most of the Robusta coffee planted on European estates up to the present has been derived from this imported type.

In Uganda it is customary to divide the Robusta coffee into the two classes: firstly, Robusta derived from seed imported from Java, and, secondly, Nganda, derived from the seed of native coffee. Usually the Robusta types form erect bushes, with a few main stems, while the Nganda types form large spreading trees, with many branches to the main stems; there are frequent exceptions—some old Robusta trees assume the spreading habit, while many of the native forms are erect.

The erect Robusta types have certain advantages: their growth is more rapid than that of the spreading type, and the trees commence to fruit early, usually producing the first crop two years after planting; also, in many cases, the size of the bean is larger. When given good cultivation these trees are very satisfactory, but if they are at all neglected they soon exhibit symptoms of die-back; after a short time nothing is left but erect bare stems with a few short primaries at the top carrying yellow leaves and very few fruits. This type is usually pruned on the multiple stem system, with three erect branches from ground level, these branches being renewed in succession as the lower primaries die off and the fruiting primaries become too high for convenience in picking.

The spreading Nganda trees are slower

in growth and seldom set much fruit until three years after planting. But it is this slow growth which enables the tree to assume a spreading habit; if the branches of the erect quick-growing Robusta types are bent over they usually break off at ground level, but the wood of the slower growing Nganda types is much tougher and is not easily broken; in fact, it is the usual custom for the natives to climb up and stand on the branches of large Nganda coffee trees when gathering the fruit.

In actual practice the spreading habit is very useful; many Nganda trees have a spread of twenty or twenty-five feet, and thus they cover a considerable area of ground around the base of the trunk, and for most of the year this ground is under relatively dense shade. This shade inhibits the growth of weeds and especially of grasses, which have a specifically bad influence on the growth of any crop. That these large trees can in fact exist without any cultivation was shown on the Sese Islands which, on account of sleeping sickness, were evacuated from 1912 until 1924, yet when the inhabitants returned, they found many of the old coffee trees still flourishing. Such control of weed growth has an important bearing on soil erosion: there is no necessity to disturb the soil, and in consequence the coffee feeding roots form a dense mat very close to the surface, holding the soil in place; whereas, when the soil is hoed to kill the weeds, these coffee roots are cut off, the soil is loosened, and considerable wash may take place.

Another important function of shade is the control of soil temperature. It has been found at Kampala that on a hot afternoon the temperature at a depth of two inches of soil under shade may be as much as 10° C. less than the temperature of unshaded soil at the same depth. Not only does this difference affect the growth of the coffee roots—a temperature of

PLATE 1.—A large old "Nganda" coffee tree on the Sese Islands.

40° C. has been recorded in the open, which is certainly in excess of the optimum for plant growth—the shading and the consequent lowering of temperature must also have a considerable effect on the soil itself; for example, in retarding the rate of oxidation of organic matter in the soil, a process which is usually excessively rapid in the tropics.

Very little pruning is given to these spreading trees in the usual native practice. About one year after the seedling is planted, when it is two or three feet high, the stem is bent over and tied down with a strip of banana fibre to a stick or a heavy stone. As a result of this bending, two or three other branches arise near ground level, and these in turn are tied down in different directions radiating from the main stem. When the tree commences to fruit, the weight of the crop pulls the branches outwards; if the centre of the tree becomes open, more branches arise there, and these in turn are trained outwards. The labour that is involved in these operations is very small in comparison with that entailed by any system of pruning. The simplicity of the method makes it particularly suitable for native cultivators, but probably it would be well worth while to try it on European estates as well, since Robusta coffee is a low-priced crop and it is essential to keep the cost of production as low as possible; an end which may be attained by the great reduction in the labour of pruning and cultivation of large spreading trees as compared with that of smaller erect bushes.

Various local terms are given to the trees by natives, some of them very apposite; for example, near Katera, in the Masaka district, there is a very old tree, whose reputation for heavy cropping is such that it is known as *Narongo,* which is the name for a woman who bears twins. Many of these terms are purely local, but others are widespread; of these there may be mentioned:—

Makọnde, a type of spreading Nganda tree, with fruits larger than usual, which is grown on the Sese Islands.

Namata, a spreading type, whose berries are a dull orange colour when ripe, not red, as is usually the case.

Musenzealanda, an erect type, whose lower primaries are very long and branching, and therefore give the tree a conical shape; the base may be as much as eight feet across. This, like the spreading habit of the Nganda types, has the advantage of shading the ground, but it has the disadvantage that many of the lower berries are hidden and that therefore the fruit is hard to pick.

The main qualities on which selection of Robusta coffee in Uganda is based are vigour (which includes resistance to disease), yield, and size of bean. Various liquoring tests on Robusta coffee would seem to show that quality depends more on the soil in which the coffee is grown and on the methods employed in the preparation of the bean than it does on any genetical factors.

With regard to vigour, in Uganda we are fortunate in possessing a number of large old Nganda trees which have flourished for a long time on native farms; such trees furnish excellent material on which to commence selection, for it is an established principle in plant breeding that the largest range of forms of a plant is to be found in the countries to which it is native. Some of the trees are very old indeed; for example, there is one on the Sese Islands which is almost certainly over a hundred years old. Its trunk has a circumference of 39½ inches at a height of one foot above the ground, and this tree still produces good crops, with beans which are above the average

in size (Plate 1). These old trees have not received much attention; no help is given to them in the way of cultivation or manuring; in fact, some of them are near houses, and the ground beneath them is swept bare every day, and yet the trees remain healthy and crop well. After such trees have fruited heavily, often they lose some of their leaves, and mild attacks of *Hemeleia vastatrix* may occur, but after a few months the tree will be again in full dark green leaf, with scarcely a spot of disease to be seen.

Yield, obviously, is of the greatest importance, and again it is highly desirable to use as mothers trees which are of mature age, for it is common experience that some coffee trees, and especially those of the erect Robusta type, will bear one or two heavy crops and then die off. It is seldom possible to obtain exact figures of yields from trees which are scattered over the countryside, but it has been found that crops of from fifty to one hundred pounds of coffee in parchment are not infrequent from these big old trees. All that can be done is to visit the trees as frequently as possible and make notes on the size of the crop, the condition of the tree, and the prospect of the next flowering; some trees have been under such observation for five years, and it is found that often there is marked biennial bearing. The shape of the tree may be a guide to its cropping powers: heavy yielders often have a large spread owing to the fact that the branches have been pulled down by the weight of the crop (Plate 2). There is another notable individual tree in the Masaka district which has a height of only about six feet, but a spread of twenty-six feet; in 1934, this tree produced about one hundred pounds of coffee in parchment.

As Robusta coffee is sold largely on the basis of appearance, and there is a distinct preference for bold samples, the size of the bean must be regarded. In this

PLATE 2.—A good type of "Nganda" Coffee: the branches are weighted down with the crop

respect many of the native coffee trees are at fault, as they produce beans which are distinctly smaller than those of ordinary Robusta coffee, but out of the hundreds of trees that have been examined it has been possible to select many whose beans are distinctly larger than those of ordinary Robusta. It is hoped that the progeny will mostly inherit this character, but that is by no means certain; for example, there is a tree at Kinawa, near Kampala, with beans averaging about 0.193 gm. in weight, but whose progeny produced beans averaging from 0.053 gm. to 0.184 gm. Again, in this connection, the advantage of having old trees to breed from is very great, as it is well known that the bean of the first few crops from a coffee bush is usually much bolder than that of successive crops.

The liquoring quality of coffee, and the factors on which it depends, present many problems. Numerous trials have been made by submitting samples of Robusta and Nganda coffee to brokers. Somewhat contradictory reports have been received, but it would seem that all the types of Robusta coffee with a good-sized bean, if properly prepared, would be saleable. For example, a report from London on Sese Island coffee prepared by natives stated that "Both these samples of coffee from the Sese Islands are of marketable quality", and a report from New York on samples of Robusta and Nganda coffee was that "As a matter of fact, all these coffees have the same general character, in the same way that all Java Robustas have the same character . . . and all of those sent would be saleable in this market." Of course, the final test of the value of any coffee selection is by the value of its progeny, and to that end progeny rows of many of the selections are being laid down. There is in existence at Kampala a plot of many progeny rows, and further batches are now being established at Kawanda, near Kampala. Individual tree records are being kept; the size of the cherry and of the bean is being measured. In a few instances the work of breeding has been greatly assisted by the discovery on native farms of plots of coffee which are the progeny of one tree, for a considerable amount of selection has been practised by the natives. From these plots a very much sounder conception of the value of a strain is obtained than is given by the inspection of a single tree.

One considerable difficulty has been found—that it is hard to assess the ultimate value of a tree by the first few crops; in selecting mother trees an attempt is made to include none under ten years old. It is not possible in ordinary breeding work to allow so long a time for each generation, therefore re-selection is based on the record of crop, the size of the bean, and the general appearance of the tree. Certain vegetative characters seem to be a good guide to the value of a tree; for example, the possession of stout branched primaries.

Self-pollination of branches enclosed in sleeves of mosquito-netting has been tried and, contrary to experience in other countries, it has given an appreciable set of crop, both in 1934 and in 1935, ranging from 45 per cent to 6 per cent, as contrasted with the average of 0.5 per cent in Java reported by Ferwerda. This degree of self fertility will be of great advantage in breeding work, and it does appear to be common in Uganda, for one may see quite isolated large old Nganda trees bearing heavy crops. Several of the strains selected in Java are being grown, and it will be of great interest to see whether these may not prove to be more self fertile in Uganda, a country which is one of the homes of Robusta coffee, than in the Dutch East Indies.

Locusts and a Rational Anti-Locust Policy *

By B. P. UVAROV, *Imperial Institute of Entomology.*

The layman's conception of locusts is that of insects which suddenly appear from somewhere in enormous swarms darkening the sky, and disappear again leaving bare ground in place of rich pasture and abundant crops. The mysterious origin of the swarms, their enormous size and the countless numbers of individuals of which a swarm is composed, all create an impression of utter impossibility of ever defeating this pest. It is exactly this spirit of hopelessness which is typical of the anti-locust policy over practically the whole world. In the great majority of countries subject to periodical locust ravages nothing is ever undertaken to prevent the appearance of swarms, and no attention is paid to locusts until the invasion reaches such an extent that the battle against it can be counted as lost before it begins. The organization for defence is designed only to save the crops and to minimize the losses. Enormous sums of money are spent on such defensive measures, and not always with success. In the Argentine, for example, the amount spent on locust control during the period 1897-1933 totalled over £11,000,000. This means that more than £300,000 on the average were spent every year, and in some years the expenditure rose to nearly a million pounds. In the Union of South Africa £1,125,000 were spent on locust control during the years 1920 to 1928, or £125,000 annually, and in the year 1934 alone the cost was £1,400,000. To these expenses must be added the cost of tens of millions of working days spent in fighting locusts by the population, who are obliged to do so by law. It should be clear that the economic aspect of the locust problem is a very serious one.

An objection can be made that locusts are not a universal pest, but occur only in some countries. As a matter of fact, however, on every continent there are only a few countries which are safe from these pests. In most of Europe, it is true, no locust swarms have occurred for nearly a century, but the Mediterranean countries are still suffering from them regularly, and a heavy outbreak is developing in southern Spain at the moment. On the south-eastern fringe of Europe, in the steppes of Russia and the Caucasus, locusts are a regular pest. Turning to Asia, the whole southern half of this enormous continent, except the highest mountains and plateaux, is ravaged by locusts from time to time: and the northern grasslands of Siberia are subject to a regular plague of grasshoppers, which are the nearest kin of locusts. The continent of Africa is wholly in the danger zone, and the devastations caused there by locusts during the last few years are well known. In South America, Argentina is not the only country that has to pay a heavy tribute to locusts, and other states of that continent suffer no less heavily. In North America, as in Siberia, locusts give place to grasshoppers, but the problem of their control is essentially the same. The smallest and the remotest continent of Australia, although still little developed agriculturally, has already had several warnings of impending catastrophies, and only last year wide areas were devastated by locusts.

Naturally, the species of locusts are not the same in every continent and country,

* Reprinted from *The Empire Cotton Growing Review*, July, 1935.

and their habits vary to some extent, but the essential features of the locust problem are amazingly similar everywhere.

The first characteristic of the problem is that the areas covered by locusts in their migrations are very much greater than in the case of most other insects. As a result, swarms arising during a given season in one country may soon spread beyond its borders and invade distant territories. An excellent example is offered by the movements of the Migratory Locust in Africa during the recent outbreak. It is now established beyond any doubt that the first small swarms of this locust arose about 1926 in the inundation areas of the Middle Niger, south-west of Timbuctu, in the French Sudan. Spreading gradually and increasing in number and size after each breeding season, the swarms soon invaded the whole of West Africa, spread into the Anglo-Egyptian Sudan, then swept into East Africa and crossed the continent once again from Rhodesia into South-West Africa. These developments may sound almost fantastic, but they have been followed year by year, and it took only five years, during which ten successive generations were produced on the way, to accomplish a double crossing of the continent and to invade the greater part of it.

Similar extensive wanderings of locust swarms have been repeatedly observed in other countries, and their complete disregard of international boundaries suggests the futility of ever finding a solution of the locust problem, except on an international basis.

The necessity of international co-operation in locust control has often been stressed, but the type of co-operation usually visualized is as useless for the real solution of the locust problem as the sporadic defensive measures practised in each country. It is often suggested in the countries spending large amounts on locust control within their own borders, that a similar energetic anti-locust policy in every other country would lead to a speedy and complete extermination of the pest. This is a complete fallacy, since the numbers of swarms, to say nothing of individuals in them, are so great that a simple calculation should show the impossibility of completely exterminating them. Indeed, if a pair of locusts produce only a hundred offspring (and this is a most conservative estimate) the destruction of even 98 per cent of the offspring would result in the number of locusts remaining the same as before. There is no doubt that this percentage of destruction is practically unattainable, except in the most densely populated and highly civilized countries. When a continent like Africa has to be cleared of locust swarms wandering over its deserts, dense bush and swamps, it cannot be hoped that success can be achieved even by a universal anti-locust campaign. The cost of such a campaign would be, of course, expressed in astronomical figures, and in some of the most dangerous areas there will not be found sufficient man-power to carry it through.

Clearly, other strategical schemes have to be devised to deal with this formidable pest. A sound basis for such schemes has been provided by some results of the more recent studies on the problem. We have seen already that in the case of the Migratory Locust the invasion involving the greater part of the continent of Africa has originated in a single relatively small area. Again, it is almost certain now that the swarms of the dreaded Red Locust, now invading practically the whole of Africa south of the equator, arose some years ago in two or three small areas in Northern Rhodesia and Tanganyika Territory. In the case of the Desert Locust, which constitutes a grave menace

to crops and most particularly to cotton, in West Africa, the Sudan, Iraq, and India, there is every reason to hope that the original sources of its outbreaks will be discovered before long, some of them being already known. The swarms of the Moroccan Locust, a dreaded pest of crops in all Mediterranean countries, in Iraq, Persia and Turkestan, may spread over whole provinces, but the swarms have their origin in narrowly defined areas, with peculiar soil and vegetation conditions. No comparable investigations intended to discover the original sources of swarms have been organized in other parts of the world, but even the incomplete knowledge in our possession of the locust problem there, leaves no doubt that the same state of things will be found everywhere. Outbreaks of locusts always commence by the formation of a few swarms in relatively small areas, with peculiar natural conditions, and the invasion then gradually spreads over the whole country and beyond its borders.

The importance of this general finding for devising a sound anti-locust policy is not difficult to understand. It means that once the *outbreak centres,* as they are called, are located, it would become a relatively simple matter to keep them under constant observation, and to suppress the incipient outbreaks in their earliest stages, when the swarms are neither large nor numerous. This policy would result in effective *prevention of invasions,* which is, of course, vastly better than the purely defensive policy which has been, and still is, practised in all the countries.

The cost of the preventive policy is certainly well under that of controlling, or attempting to control, the swarms which have spread over the whole country, while in addition all losses to crops would be eliminated.

The difficulties in organizing a preventive control of locusts, as outlined above, are mainly psychological and political. It is a common human failing that a danger is seldom realized until it is too late, and it is easily forgotten when it is past. Since locust swarms appear only periodically with clear intervals of several years, it is not easy to persuade those whom it concerns to spend even a small amount in order to prevent an invasion when there is as yet no sign of it. Once the swarms appear and a panic sets in, the costs are not counted, and money and labour are wasted in the hopeless struggle against an overwhelming enemy. When the swarming period is over a victory is proclaimed, and it becomes practically impossible to convince those in authority that the respite is only temporary and a new invasion is certain to come within a few years. It finally comes "unexpectedly", and the whole story begins all over again.

Until recently, this short-sighted policy had its justification in the insufficient knowledge of the habits and the sources of locust swarms. Now, as we have seen above, it has been convincingly demonstrated with regard to several locust species that the policy of prevention can be based on the soundest possible foundation.

The first step towards such a policy in the case of each species of locusts would be a thorough investigation of the course of invasions, in order to discover the outbreak centres. Owing to the disregard of all boundaries by locust swarms, these investigations must be international in their scope and cover the whole territory over which the particular locust species can migrate. It is exactly on this basis that the locust investigations in Africa and Western Asia have been organized by the British Government. The countries within that immense territory agreed to submit monthly reports on the

locust situation to the Imperial Institute of Entomology, London, which is recognized as the International Centre of Anti-Locust Research. These reports, accompanied by maps showing the breeding places and the movements of swarms, are carefully studied, and general maps and reports are prepared. These summary reports permit the Institute specialists to discover the main lines and directions of migrations, as well as the areas suitable for breeding. By following the reports back to the earliest stages of the invasion, it proved possible to trace the swarms to their original sources or the suspected outbreak centres.

The next step was to investigate these supposed outbreak centres on the spot, and to define them more closely. Several entomologists entrusted with this task were sent by the British, French, Indian and Belgian Governments to carry out these investigations. Some areas have already been surveyed and important practical conclusions have been reached, but the territories to be studied are very extensive and some of them difficult of access. The work is therefore not yet accomplished, though the end can be visualized within the next few years.

With regard to one locust, however, the Migratory, the task of preliminary surveys can be considered completed, and the problem of that locust is already ripe for a practical organization of preventive control. It is, however, one thing for the scientists to show the rational way to the solution of a problem, and quite another to hope that the necessary steps will be taken to reach it. In this particular case the difficulties in the way of practical steps are aggravated by the necessity to create an organization which would be international in its scope. When a single outbreak area presents a source of danger to the whole continent, it is only natural that all countries should take an active part in organizing the permanent control in that area. The task of creating such a permanent organization appears a difficult one, but it belongs to the sphere of politicians, not of entomologists.

The case of the Migratory Locust in Africa is, however, an extreme one. With some other species the problem is less formidable, since they are more localized, and often an outbreak area supplies locust swarms only to a single country. Such is the case, for example, with the Moroccan Locust, a notorious pest in some cotton-growing countries. The present writer's investigations in Turkey and Iraq, and M. Pasquier's detailed studies in Algeria, proved definitely that this locust can be easily kept under control in a single country. Indeed, an organization for the supervision of outbreak centres is already functioning in Algeria, and there is every reason to think that this means the end of invasions of that country by this locust. The cost of the permanent organization, which should be counted as an insurance premium against invasions, is very slight, compared with the periodic expenses of controlling the invasions. Unfortunately, other countries, even where the preliminary research work has been done, still prefer the time-honoured system of waiting for swarms to begin their ravages before anything is done to control them.

To conclude, the investigations and the experience of the last few years go a long way to prove that the great locust problem is not impossible of solution. This solution can come, however, only through a broad organization of research into the original sources of outbreaks. The investigations should supply the essential facts for developing a comprehensive preventive policy in the natural area of each locust species. In both stages of work, the success depends on an effective international co-operation, and on an

efficient central organization. Given these two conditions, the locust problem will soon lose its tremendous importance, though a constant vigil will be necessary in the outbreak areas.

It is a hopeful sign that the idea of international co-operation in anti-locust research designed to develop a preventive policy is now finding an almost universal recognition. This policy has been fully endorsed by an international locust conference held in London in 1934 at which thirteen countries were represented. At the next conference, to be held at Cairo in 1936, it is hoped to extend the international anti-locust schemes to all the countries of the world suffering from this oldest and greatest enemy of agriculture.

Agricultural Statistics in Kenya

By V. LIVERSAGE, *B.Sc. (Lond.), M.S. (Wis.), N.D.A., Agricultural Economist, Kenya.*

Modern developments in the design of tabulating machines have greatly enlarged the scope of the statistical work which can be carried out with a reasonable expenditure of labour and time, and have brought within the bounds of possibility a degree of analysis which was previously out of the question.

The availability of Hollerith tabulating machines in Kenya has been turned to account in enlarging the range of information which the annual Agricultural Census can be made to yield. The census is confined to farms in the occupation of Europeans, and is carried out by the postal questionnaire method, the results being compiled in a manner somewhat similar to that followed by the Ministry of Agriculture in England. For machine tabulation the information contained in the completed schedules is transferred to cards which, by a simple mechanical process, can be sorted in any desired grouping and contained data automatically tabulated. The cost of additional regroupings represents an insignificant addition to that of the initial preparation of the cards.

The conventional method of tabulation results in division of the data by districts, but several different types of holding are comprised within the district figures, and little information is secured as to the economics of particular sections of the agricultural industry. With a view to filling in this hiatus the schedules received in connection with the 1932 census were coded in accordance with the type of farming carried on.

It was necessary to keep down clerical work to a minimum and consequently it was impossible to adopt a basis of classification which involved preliminary calculation of the proportion of land under various crops, or of other similar factors for each individual farm schedule. It is theoretically possible to base a classification on the absolute factors contained in the schedules, the cards being sorted direct by mechanical means. In practice this would involve a rather minute subdivision, and in this instance insufficient space remained on the cards for the necessary code numbers. Resort was therefore had to an empirical method of classification by inspection which, owing to the relatively simple organization of farms in the Colony, proved reasonably successful. No attempt was made to draw up a "natural" classification of farm types, as it were, but the object pursued was rather that of obtaining the maximum amount of economic information. Though the resulting classes were not quite clear-cut, the degree of overlapping of enterprises in most cases was negligible. For instance, the maize class included some other crops and some live stock other than work oxen, but the amounts concerned were so small in comparison that the figures could be used to calculate, for instance, the labour requirement per 100 acres of maize, without fear of any considerable inaccuracy. The relevant figures for this class (which refers to specialized maize farms, and does not include mixed farms on which maize is grown) were as follows:—

	Acres
Area of maize harvested	47,246
Area of beans and peas harvested..	393
Area of green manure crops.. ..	2,061
Area of other crops	2,401
Area of fallow	10,792
Area under cultivation	62,893
Number of work oxen	8,395
Number of other cattle	154

The number of labour units employed was 5,469, and it is sufficiently near the mark to say that the labour utilization for maize was 11.6 units per 100 acres of maize, or 8.7 units per acre under cultivation. Unfortunately, in this instance, there was an unusual discrepancy due to the fact that a certain area of maize was destroyed by locusts but still appeared as fallow land in the area under cultivation.

Reliable information of this description, of course, can only be obtained directly where a sufficient number of specialized holdings are present. It was fortunate from the point of view of analysis—though perhaps not so fortunate for the agricultural industry—that the various crops and live stock enterprises were represented by a fair number of holdings devoted almost exclusively to them. Thus the labour requirements and other similar factors could be worked out from groups of specialized maize, wheat, coffee, sisal, sugar, tea, dairy, cattle-raising and sheep farms.

The information obtained in the whole analysis was encyclopædic, but may be illustrated by a few extracts relating to matters of more general interest.

The first step was to get an idea of the comparative importance of the various types of farming, and to this end a table was constructed, of which the following are a few of the more important items:—

DISTRIBUTION OF FARM TYPES IN KENYA

(European Area)

Type of Farm	No. of holdings	Area occupied	Area per holding	Area under cultivation	Proportion of land under cultivation	Native labour employed	Native labour per 100 acres occupied
		Acres	*Acres*	*Acres*	*Per cent*	*Units*	*Units*
Coffee	471	384,118	815	72,780	19·0	31,043	8·082
Coffee and mixed crops	294	463,392	1,576	97,843	21·1	15,577	3·361
Coffee, mixed crops and cattle	106	242,611	2,288	27,785	11·5	6,473	2·668
Coffee and sisal	18	96,109	5,339	38,594	40·2	3,381	3·518
Sisal	51	516,609	10,129	106,671	20·6	6,245	1·208
Wheat	62	97,110	1,566	19,319	19·9	902	0·926
Maize	151	276,506	1,831	62,893	22·7	5,468	1·977
Mixed farming—							
Crops only	144	240,913	1,673	49,459	20·5	3,721	1·547
Crops and cattle	145	446,465	3,079	57,639	12·9	5,845	1·309
Grass dairying	232	893,217	3,850	12,087	1·3	5,568	0·623
Cattle raising	46	226,415	4,922	5,103	2·3	1,052	0·465
Wool production	6	151,858	25,309	326	0·2	224	0·147
Tea	21	53,096	2,528	12,011	22·6	9,796	18·449
Total	1,207	5,199,093	2,467	613,557	11·8	104,120	1·960

Some examples of labour requirements on different types of farms are shown below:—

Type of Farm	Labour units employed
Coffee—	
Per 100 acres under coffee ..	48·8
Per 100 acres under cultivation..	42·6
Per ton of coffee produced ..	5·0
Maize—	
Per 100 acres of maize harvested..	11·6
Per 100 acres under cultivation..	8·7
Wheat—	
Per 100 acres of wheat harvested..	7·5
Per 100 acres under cultivation..	4·7
Sisal—	
Per 100 acres under sisal ..	6·2
Mixed farming—	
Crops only: per 100 acres under cultivation	7·5
Crops and cattle: per 100 acres under cultivation	10·1
Grass dairying—	
Per 100 cows and heifers over 3 years	16·1
Per 1,000 gallons of milk produced	1·8
Cattle raising—per 100 cattle ..	4·7
Wool production—per 1,000 sheep..	6·0
Tea—per 100 acres under tea ..	90·9

It is possible that the data obtained in this way may in some cases be useful as evidence of the desirability of certain practices. A considerable degree of caution is necessary in drawing conclusions from the figures, however, as may be aptly illustrated in the case of the coffee industry. It is stated that there is a grave danger in coffee-growing of depleting the stores of humus in the soil, resulting not only in impoverishment of the soil but also in reduction of its water-holding capacity—a highly important factor. It might be supposed that a comparison of the yields obtained on specialized coffee farms with those on which cattle are also kept might have thrown some light on the question. In the situations most favourable for coffee culture, however, the land is so valuable that it cannot be put to such low-value uses as maintenance of cattle, and in consequence high yield of coffee is directly correlated with the degree of specialization.

It becomes possible to form a picture of any type of farm as an economic unit. Taking, for instance, the grass dairy farm, the following items were extracted:—

Average area per farm	3,850 acres
Area under cultivation per farm	15 „
Native labour employed per farm	24 units
Native labour employed per 100 cows	16·1 „
Number of cows and heifers over 3 years	150
Number of heifers, 1–3 years ..	55
Number of heifers under 1 year..	38
Number of working oxen ..	24
Number of bullocks	56
Number of other cattle and calves	40
Number of wool-bearing sheep..	82
Number of other sheep	26
Number of pigs	15
Number of poultry (all kinds) ..	66
Dairy produce in equivalent of butterfat per farm	4,716 lb.
Dairy produce in equivalent of butterfat per cow	31 „

The census schedules cover almost all the items of capital goods and production, and also the native labour and European supervision employed. It is possible to get an approximate idea of the economic position of any branch of the industry by applying estimated money values to the physical data obtained. Relatively few blanks, and most of those relatively unimportant, remain to be filled in.

It may be objected that the averages obtained may cover such a range of variation as to be almost meaningless. In some cases this is doubtless true, though in one or two instances, where it has been possible to check the figures against data obtained in the course of economic surveys, the averages have represented fairly closely the general run of cases. It is, however, as easy to obtain frequency distributions as averages by machine tabulation. An example is afforded by the sizes of farms in Kenya, which are shown in the following table:—

(*Continued on page* 211)

Virus Diseases of East African Plants: III.—Rosette Disease of Groundnuts

By H. H. STOREY, *M.A., Ph.D., Plant Pathologist, East African Agricultural Research Station, Amani, Tanganyika Territory.*

The rosette disease of the groundnut plant (*Arachis hypogaea* L.) was first recognized in the present Tanganyika Territory (Zimmermann, 1907, 1913). Since then it has been observed throughout the countries of tropical and southern Africa wherever groundnuts are grown. Similar diseases—although not certainly identical with rosette—have been reported as "clump disease" in India (Sundararaman, 1928) and "krulziekte" in Java (Rutgers, 1913).

The disease is of great importance in the culture of groundnuts. An extensive outbreak causes heavy losses. In one district at least, in South Africa, the uncertainties produced by periodic outbreaks led to the abandonment of this otherwise remunerative crop.

Work in South Africa, begun in 1923, led to the proof that rosette disease is caused by a virus (Storey and Bottomley, 1928). This conclusion has been widely confirmed in other countries, although adherents to the previously held view that the disease was to be attributed to physiological causes have not been lacking (Trochain, 1931).

THE SCIENTIFIC ASPECT.

(1) *The Effects of the Disease.*—The most marked effect of the rosette virus is to cause an extreme reduction in the growth of the plant; the leaflets become small and twisted, the petioles shortened and the extension of the axis almost ceases. In consequence the branches come to bear dense tufts of small leaves (Fig. 1). No true proliferation takes place, although axillary buds may grow out into short rosetted shoots which add to the clumped appearance.

The small stunted leaves on opening remain for some time a pale lemon-yellow colour. Later, however, they gradually develop a normal green. Consequently during periods favourable for rapid growth the most striking character of the disease is the bright yellow colour of the affected plants; at other times no noticeable yellowness may be apparent.

From the time of onset of the disease the plant may continue to flower, but it sets no fruits. The only yield from a diseased plant is the seed which had formed before the plant contracted the disease.

The foregoing description applies to the typical form of rosette. Other forms have been described. In South Africa, plants were encountered in which the leaves, instead of being uniformly yellow, developed a mosaic-like mottling (Fig. 2) (Storey and Bottomley, 1928); such plants were markedly less stunted than the type. The explanation of this difference is not certain; I am now inclined to doubt whether the argument advanced in the paper mentioned, that the difference is due to variation in the reaction of individual plants, is valid. We may suspect that, as is found so frequently, strains of the rosette virus of varying virulence may occur.

In the Gambia, Hayes (1932) recognized three forms of rosette: (1) Chlorosis rosette, similar to that described above; (2) Green rosette, in which the leaves are never chlorotic but are darker green than normal; and (3) Rosette type 3, with leaves of normal colour but stems much thickened and curved in a clock-

wise direction. Each form was shown to be transmissible by grafting without change. They must represent differences in the viruses that cause them; we may suspect again that several strains of one virus are concerned, although evidence of insect transmission, which would be the best confirmation of this point available to us, is lacking.

(2) *Transmission of the Disease.*—All workers with this disease are agreed that the virus is not carried in the seed, nor can it survive in the soil and thence pass to the plants. Experimentally, it cannot be transmitted by mechanical inoculation of juice. The virus will, however, pass a graft, and this provides a certain method for experimental infection (Storey and Bottomley, 1928; Hayes, 1932).

Natural spread of the rosette virus is due to insect-vectors. In South Africa the vector was proved to be *Aphis laburni* Kalt. (Storey and Bottomley, 1928, where this insect was referred to by its synonym, *Aphis leguminosæ* Theo.), and similar results were obtained in Tanganyika and in Uganda. No other species of insect has been proved to transmit this virus. Certain leafhoppers were tested without success in South Africa, and for a time three species of leafhoppers were suspected to be the vectors in the Gambia (Brooks, 1929). The suggestion of several vectors by Mayné and Ghesquière, in the Belgian Congo (1934), appears to rest on no experimental evidence.

Aphis laburni, in common with other

FIG. 1.

Healthy and diseased groundnut plants, variety, Virginia Bunch. Note the crowded masses of small leaves at the tips of the shoots of the rosetted plant.

aphids, is capable of extremely rapid multiplication. In South Africa groundnut plants might often be seen almost hidden by large colonies. In East Africa, however, I have never seen such heavy infestation, and often a prolonged search reveals only few small colonies. This comparative rarity of the insect has caused some doubt whether it can be held responsible for the wide spread of rosette. Doubtless infestation by this insect is largely held in check by the great activity of natural enemies—a matter which, as we shall see, has probably an important bearing upon the control of rosette. In South Africa the most important enemy was the predaceous larva of a Syrphid fly, the adults of which might sometimes be seen in great numbers in groundnut fields. Syrphid flies and a hymenopterous parasite have been recorded on *Aphis laburni* in Uganda (Hargreaves, 1933). In August, 1931, I found in Uganda that, while insect predators were rare, the aphids were freely attacked by a parasitic fungus, *Entomophthora aphidis* Hoffman. I suspect that this fungus is the chief natural agency of control, and that its activities are favoured by the ecological conditions produced by a close cover over the ground. To this feature I attribute the proved advantages of close planting of the groundnut crop. This explanation is not certain, however, and it is possible, as others have suggested, that close planting in some manner increases the resistance of the plant to the virus.

(3) *The Range of Plants Affected.*—All known varieties of groundnuts, both of the bunch and spreading types, are susceptible to the rosette virus. Extensive trials in South Africa of a large number of standard varieties failed to show any with exceptional resistance, and this has generally been the experience in other countries. In the Gambia, trials led to the claim that a variety, Philippine Pink, was resistant under local conditions (Brooks, 1932); but this variety proved to be fully susceptible when tested in Natal (A. P. D. McClean, *in lit.*). Experiments in Uganda appeared to show a slightly higher inherent resistance in the bunch type than in the spreading (Hosking, 1933).

Under thsse circumstances, the prospect of obtaining a resistant strain by selection is not promising. Four years of single plant selection gave no encouragement in Natal (McClean, *in lit.*). Work on these lines has been undertaken in Uganda, but no successful outcome has been reported (Jameson, 1934).

No other species of plant has been proved to be susceptible to the rosette virus. A number of plants, both leguminous and of other families, have been held under suspicion, but attempts at Amani to transmit the rosette virus to them always failed. The reports of a long list of plants affected with rosette in the Gambia (Brooks, 1932), and with "Krulziekte" in Java (Rutgers, 1913), are based on no experimental evidence.

The Practical Aspect.

(1) *Recognition of the Disease.*—A groundnut plant markedly retarded in growth by comparison with its fellows should be held under suspicion as affected with rosette disease. If the typical form of rosette is present, confirmation of the diagnosis is easy. The branches, instead of making normal growth, will be found to have ceased extension abruptly and to bear at their ends a mass of small, somewhat distorted leaves (Fig. 1). Under favourable conditions they may be a bright yellow in colour, but at other times they may be a nearly normal green. The mosaic form of the disease is easily recognized if the plant is making rapid growth (Fig. 2); if growth has been checked the mosaic

pattern may be difficult to see, but the leaflets remain somewhat crinkled and smaller than the normal, although the extreme stunting seen in typical rosette will not be present. Too little is known at present of other forms of the disease to allow of simple directions for their recognition. Indeed, I have seen small stunted plants, without any of the characteristic symptoms of rosette, to which a definite diagnosis could not be given. In practice, however, the typical rosette is most often encountered, and is the form responsible for most of the losses in the groundnut crop.

It should be noted that the commonly encountered sudden wilting of groundnut plants, so that within a day or two they are dry and brown, is unrelated to rosette.

(2) *Control of the Disease.*—The control of rosette disease is a problem to which the general principles stated in the first part of this series of articles may be applied. In the first place, however, the simple method of growing a resistant variety is not available, since no variety is known to exhibit any marked resistance. Efforts must therefore be directed to protecting the plants from infection.

As I have shown, transmission in the field can occur only through the agency of the insect-vector, *Aphis laburni*. If we can prevent dissemination in the fields of aphids *bearing the virus,* we can control the disease. An essential point is then

FIG. 2.
Groundnut plant, variety, Virginia Bunch, showing the mosaic-like form of rosette disease.

the source whence the aphids which enter the fields may obtain the virus.

It is possible that some plants of the weed-flora may harbour the rosette virus. But of this we have no evidence. The one certain source of the virus is groundnut plants, and if, at the time of planting, it can be arranged that there are no groundnut plants surviving in the neighbourhood, then an important, and probably effective, step can be taken. This measure is particularly applicable in regions where cold or drought enforces a long close season against the growing of groundnuts. In the sub-tropical Transvaal a cold dry winter intervenes between each growing season. Nevertheless, I was able to show (Storey and Bottomley, 1928) that small groundnut plants, growing from self-sown seed at the end of the season, might survive the winter, and that, contracting rosette at the end of the season, they might still be growing diseased at the beginning of the next. The more severe the winter, the fewer diseased plants might be expected to survive. In fact, it was found that the seasons of severe rosette outbreaks were those that followed winters of unusually heavy rainfall. On the basis of a few years study only, it appeared to be possible to predict the intensity of the rosette infection from an examination of the rainfall figures of the preceding winter.

Such considerations can have only a limited application in tropical countries. But in regions where a long close season is imposed by drought the same principles may be found to apply. In any case, it is worth while to take every possible step to ensure the destruction of groundnut plants that may grow from self-sown seed in old groundnut lands. If these are permitted to survive until the new crop is planted, a certain source of the rosette virus is left available.

To obtain the full advantage from these precautions, it is necessary that planting of the crops be done as nearly as possible on one date throughout the district. Failing this, the early sown plants, of which some will inevitably contract rosette, will act as a source of the virus for late sown plants. For this reason great stress is laid on the importance of early planting, both in South Africa and the Gambia (Brooks, 1932). I believe that the importance rests, not on earliness itself, but on uniformity.

Hitherto we have considered measures that may reduce the number of *infective* insects in a groundnut plot. We will now consider what steps may be taken to reduce the total aphid population. As is usual, direct methods to control the insects are out of the question. But it appears that a method is open to us whereby we may encourage the natural enemies of the insect to exert the control desired.

This is the method of close planting. Experiments carried out in the Gambia (Ann. Rept. Dept. of Agric. for 1930-31) and particularly the very extensive series undertaken by the Uganda Department of Agriculture (Ann. Repts. for 1931, 1932 and 1933) have shown conclusively that rosette infection can be greatly reduced by adopting a close sowing distance. This procedure, it is true, was arrived at empirically—indeed, it is the usual practice of the native cultivator in Uganda—and the suggestion that it works through the control of the insect-vectors is no more than an attempt to explain an observed effect.

The essential point in this procedure appears to be ensuring a close cover of vegetation over the ground as soon as possible. A dangerous period must occur therefore during the early growth of the young plants, however close the sowing. Two means of overcoming this have been

suggested: mulching the soil surface with dry grass, and encouraging weed growth during the early period. Both systems are adopted by certain tribes in Uganda. The experiments of the Uganda Department of Agriculture, however, led to the conclusion that any advantage given by mulching did not justify the cost of the process (Ann. Rept. for 1932, p. 11). Postponement of weeding appears not to have been given experimental trial in Uganda, but in the Gambia an experiment showed it to be highly effective in controlling rosette (Hayes, 1932). It is possible that this practice may be of value in East Africa; but it remains to be found how long the weeds may safely be left before their competition is seriously felt by the groundnut plants. In this connection, Hayes (loc. cit.) considers the possibilities of selective weeding, leaving only those weeds least harmful to the crop, and of interplanting the groundnuts with a quick maturing cereal.

We may thus summarize the measures that can be recommended at present to control rosette as follows:—

(1) Take all possible steps to destroy self-sown groundnut plants during the off-season, when no groundnut plants are being grown.

(2) Adopt as far as possible a uniform sowing date throughout a district.

(3) Sow groundnuts at a close spacing. In Uganda, a 9 in. x 9 in. spacing gave maximum yields, but it is uncertain whether even this represents the optimum closeness (Ann. Rept., 1932, p. 11).

REFERENCES.

Brooks, A. J., 1929.—Ann. Rept. Gambia Dept. Agric. for 1928-29, p. 12.
Brooks, A. J., 1932.—Ann. Rept. Gambia Dept. Agric. for 1931-32, p. 9.
Hargreaves, H., 1933.—Ann. Rept. Uganda Dept. Agric. for 1932, p. 53.
Hayes, T. R., 1932.—Trop. Agriculture, V. 9, p. 211.
Hosking, H. R., 1933.—Ann. Rept. Uganda Dept. Agric. for 1932, p. 41.
Jameson, J. D., 1934.—Ann. Rept. Uganda Dept. Agric. for 1933, p. 32.
Mayné, R., and Ghesquière, J., 1934.—Ann. Gembloux, Jan., 1934.
Rutgers, A. A. L., 1913.—Meded. Afdeeling Plantenziekt, No. 6, p. 1.
Storey, H. H., and Bottomley, A. M., 1928.—Ann. Appl. Biol., V. 15, p. 26.
Sundararaman, S., 1928.—Madras Agric. Dept. Year Book, 1926, p. 13.
Trochain, J., 1931.—Rev. Bot. Appl. et d'Agric. Trop., V. 11, p. 330.
Zimmermann, A., 1907.—Der Pflanzer, V. 3, p. 129.
Zimmermann, A., 1913.—Der Pflanzer, V. 9, p. 59.

Agricultural Statistics in Kenya

(*Continued from page* 205)

Area of Farms	No. of Farms
Acres	
Not stated	37
0–49	83
50–149	95
150–499	419
500–999	395
1,000–4,999	846
5,000–9,999	158
10,000–19,999	41
20,000 and over	33
TOTAL ..	2,107

Acknowledgment is made to Mr. W. H. Moran, the representative of the Hollerith Company, for assistance in devising a scheme of classification and carrying out the machine tabulation.

The Preparation of Shade-Dried Hides and Skins

By H. E. EMSON, *Department of Veterinary Science and Animal Husbandry, Iringa, Tanganyika Territory.*

BUILDINGS.

For the preparation of shade-dried hides and skins it is necessary to have a suitable building. Where possible, buildings of a permanent design should be constructed, as temporary buildings offer a number of disadvantages: they require continual repair, are often broken into by wild animals and dogs, and are not as a rule weatherproof. It is obvious that these disadvantages must affect the finished article, and if a standardized product of good quality is aimed at the solution is permanent buildings. Thatched buildings are more suitable than those covered by corrugated galvanized iron, as they are not subject to such extremes of temperature. To make the building really rainproof, thatch should be laid on at an angle of 45 degrees; all timber should be of wood resistant to white ants and borers, and should be treated with solignum before being used.

The size of the building will naturally be governed by the supply of hides and skins. A plan of a suitable shade-drying shed is appended. This building is designed to take 12 hides and 12 skins at a time. In addition to this shed, a small godown is required for storage of hides and skins after their removal from the shed. This should be a building with a cement floor, and should be weather and vermin proof.

PREPARATION PRIOR TO DRYING.

Slaughtering.—Great care must be taken when bringing the animal to slaughter to ensure that the hide or skin is not damaged by beating, or by dragging the animal along the ground. Many hides are completely ruined in this way.

The animal should be thrown as gently as possible, and after the jugular vein has been severed the carcass should be allowed to drain until the flow of blood has completely ceased.

Flaying (Hides).—The carcass should be placed on its back and the hide opened up with a sharp knife from gullet to anus. Cross cuts are then made from hock to hock, running the knife down the outside of the leg and across the buttock.

The hide opened up ready for flaying

In the same way, a cut is made from knee to knee, this time running the knife down the inside of the leg and across the brisket. The shank ends should be cut off. The hide is now shaped ready for removal. Extreme care must be taken in flaying, as many hides are badly damaged during this process through slitting and gouging in an attempt to remove as much meat as possible.

It is far better to leave a little meat on the hide than to try to take off too much; surplus meat is easily removed later during the hanging and cleaning process. Various methods of flaying have been advocated, including elbowing the hide off or knocking it off by the employment of a wooden mallet. Anyone who has tried either of these methods will realize how unpractical they are when dealing with the average East African ox, which lacks subcutaneous fat. In the opinion of the writer, it is much better to use a sharp knife, and to take extra care while doing so.

The correct method of skinning a sheep or goat.

Preparing for Hanging.—Having removed the hide, the tail should be cut off together with odds and ends, such as scrotum and sheath. The next process is to make incisions round the edge of the hide for hanging purposes. These incisions should be made at all the extreme portions of the hide, as this saves considerable trimming when it is eventually hung in the frame and also gives the hide a better shape.

The portion of the edge of the hide at which it is desired to make an incision should be wrapped half round a small stick, the hair side being next the stick. It is then easy to make an incision about one inch long on the flesh side with a sharp knife. If a stick is not thus used, it will prove difficult to make the incision.

This process is repeated until the required number of incisions have been made, usually about 35 for a hide or 25 for a sheep or goat skin.

If a cement floor is available, the hide should be placed flat upon it, and scrubbed on both hair and flesh sides with plenty of fresh clean water until all blood and filth are removed. If no cement floor is available, then the hide must be washed as well as possible under whatever circumstances prevail.

The hide is now ready for hanging in the frame, and it should be removed to the drying shed as soon as possible.

Skins.—The method described for hides also applies to sheep and goat skins, with the exception than in skinning a knife should only be used for opening up the skin. The skin itself is then prised off by using the closed fist.

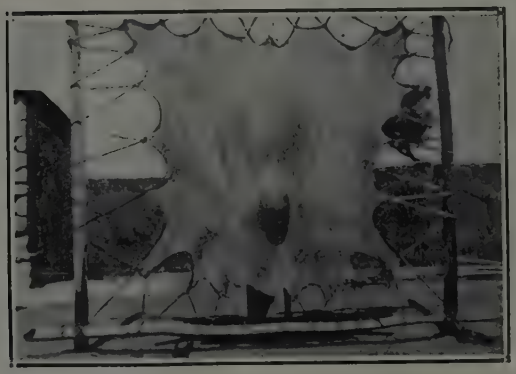
Hanging and Cleaning.—A few short pieces of rope are now required for tying the hide temporarily to the frame. The hide should be hung neck downwards, with the hair side to the inside of the frame. The four legs should be tied to the four corners of the frame; this gives the hide a good shape when dry.

A long rope should now be taken and threaded through the incisions and round the frame, the temporary ropes then being removed. Over-stretching should be avoided; the hide should be just tight enough to keep it in good shape in the frame. As it dries out it will tighten up naturally. Over-stretching

damages the tissues, and is detrimental to the finished leather.

Having laced the hide into position in the frame, the hump should be stuffed with grass and a piece of wood should be stayed from the ground into the hump to keep the grass in position. If it is desired to hang two hides to one frame this can be done by hanging them hair side to hair side. A stick of 1½ in. in diameter and 1½ to 2 ft. long can then be placed from hump to hump to keep the grass in place, and to allow a passage of air between the two hides. The hump itself is of little value for leather purposes, but if it is kept in shape and properly cleaned there is less likelihood of putrefaction setting up in this portion of the hide.

Washing the hide after removal from the carcass



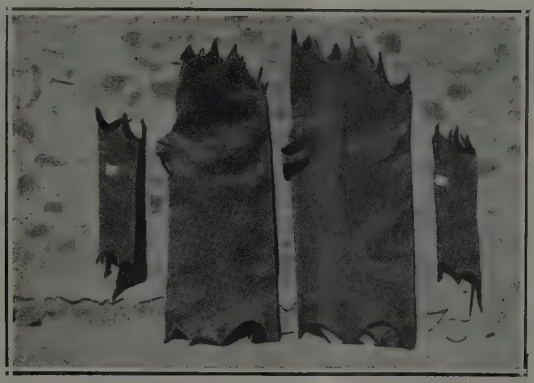
A well hung and cleaned hide.
Note thin stripes of lean left on.

The next process is to remove the surplus meat, etc. This should be done with a sharp knife, and special care must be taken that it is not overdone. On the back at the butt end of most hides there are stripes of lean. These should be left on, as attempts to shave them off invari-

ably result in gouging, with consequent damage to the hide. All oddments taken from the hide must be disposed of, and the shed swept clean daily in order to keep down the number of flies and other insects.

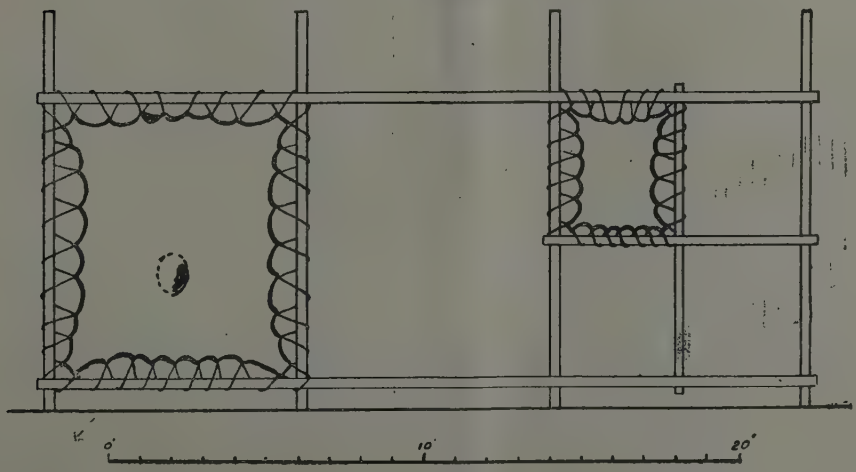
Drying.

As a general rule, a hide will dry out in about 7 days in the dry season and in 10 to 14 days during the wet season. The best method of ascertaining whether a hide is properly dry or not is to feel the thick portions near the neck and also where the extremities are threaded to the frame. If these are dry, and there is no "hair slip", then the hide is ready for removal from the frame. The same method applies to sheep and goat skins,

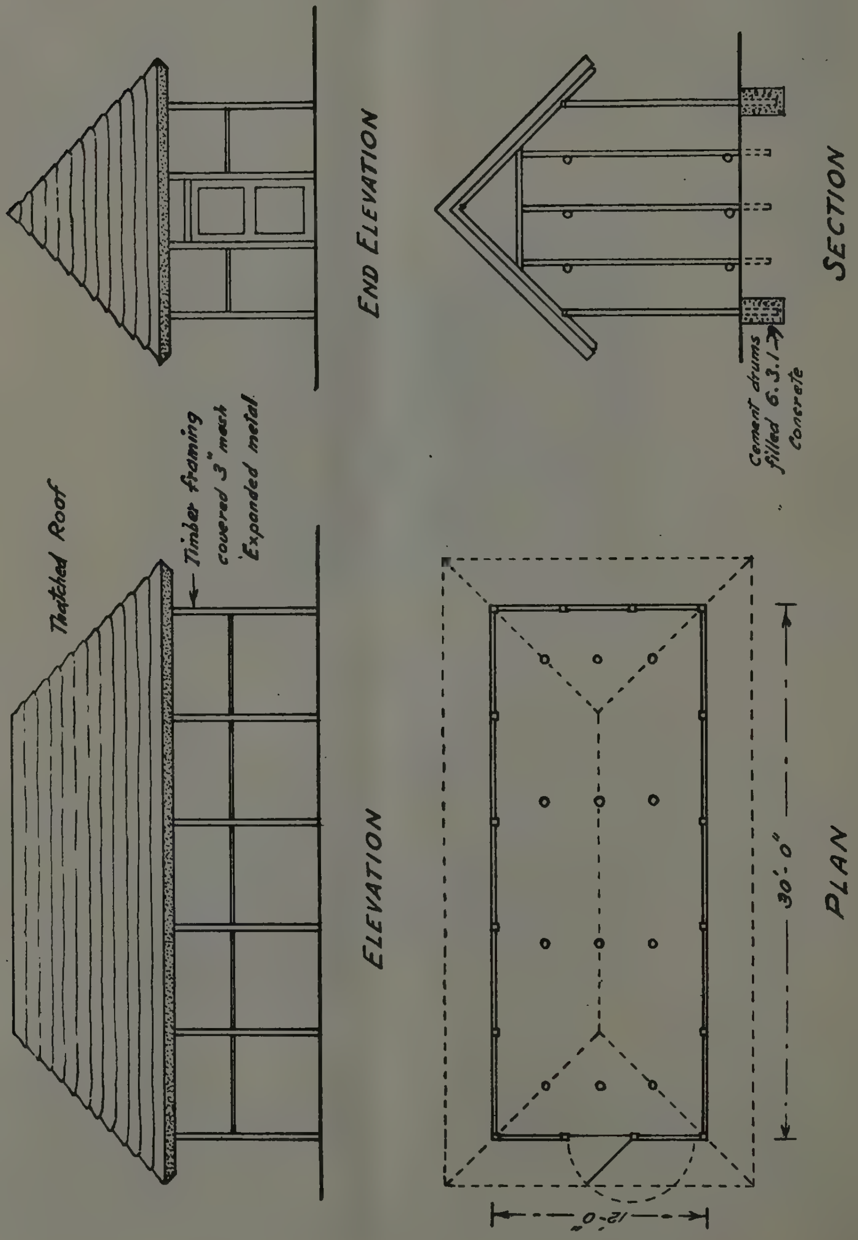


Hides and skins folded ready for despatch to the coast.

SKETCH OF HIDE AND SKIN LACED TO FRAME



SHADE DRYING SHED FOR HIDES AND SKINS



which usually dry out in 4 days in the dry season and in 6 to 8 days in the wet season.

Having removed the hide or skin from the frame, it should be placed flat upon the floor, hair side upwards, and should then be well brushed with a stiff brush. This removes all dust and dirt, and gives a nice sheen to the hair, which adds to its attractiveness.

When weather permits, hides and skins that have been shade-dried should be placed in the sun for a few hours for two or three days in succession. This completes the drying process, and also disinfects the hide or skin.

Folding.

The most valuable side of a hide or skin is the hair or grain side. For this reason they should be folded with the hair side inwards. A straight fold should be made down the middle, and then about 9 inches of the flanks should be folded in. This tucks away the extremities, and makes a nicely shaped article which is easily handled.

Storage.

Hides and skins should be disposed of as soon as possible after drying. A good practice is to sell them every month. Care must be taken that they are well aired and that insects do not get into them. When weather conditions are favourable they should be taken from the godown and exposed to the air and sun at least once a week, and at the same time they should be examined for insects.

If disposed of every month and properly cared for during the time they are in the godown there is little risk of damage, but where it is necessary to store them for some time a sprinkling of powdered naphthalene should be placed between each piece on the hair side.

Stephanoderes Hampei Ferr., Coffee Berry-Borer, in Uganda

By H. HARGREAVES, *A.R.C.S., D.I.C., F.R.E.S., Government Entomologist, Uganda.*

This berry-borer is one of the most important pests of coffee, both *arabica* and *robusta*, growing in Uganda at altitudes up to about 4,100 ft. With increase of altitude over this figure it diminishes in incidence, and at 5,000 ft. is so rare that it cannot be considered a pest.

Except under certain conditions which will be discussed later, parasites, two species of which are known, hold the pest in check for considerable periods, so that occasional berries only may then be found infested with the beetle.

Stephanoderes bores into the coffee berry to feed on the seed, and it is only after the seeds are sufficiently developed to be hard that the insect can live and breed in them. In the absence of hard seeds, or where the borer population is in excess of that which the more nearly mature berries will support, the beetle will attack green berries of any age.

The fact that the beetle spends most of its life protected inside coffee berries greatly restricts the possibilities of direct chemical control, and such measures as have been advocated in Uganda have been directed mainly towards assisting and encouraging the parasites by making the environment favourable for them.

Outline of the Life-history of the Beetle.—The female selects a suitable berry, bores a clean-cut circular hole about 1/32 in. in diameter (about half the diameter of a pin-head), almost always at the tip of the berry, and enters a bean near the outer end. After boring a short distance into the bean, egg-laying is begun in the tunnel so formed; the beetle continues to bore and lay eggs in that bean until further food is necessary and the second bean is then attacked.

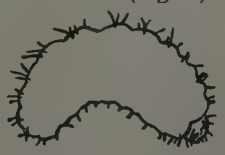
The eggs hatch after 8 or 9 days, and the larvæ feed on the tissues of the bean, making small tunnels, for about 15 days in the case of the future male and up to 19 days in the case of the female, after which the grubs remain quiescent and become pupæ. No cocoon is made. The pupal stage extends over 7 or 8 days, after which the skin splits and the adult beetle emerges. The adult rests until its skin is hard and, if food is available, it continues to feed in the same bean or berry and breeds there until the food is exhausted. Pairing occurs within the berry where the beetles have been bred. A period of 5 to 30 days may elapse before newly emerged females begin to lay.

Description of the Young Stages of the Beetle.—The egg (Fig. 1) is translucent white, about 1/40 in. long and

Stephanoderes hampei
Fig. 1—egg × 20

1/100 in. at the widest part, with one end more sharply rounded than the other. It is visible without the assistance of a lens.

The grub or larva (Fig. 2) is creamy-



Stephanoderes hampei
Fig. 2—larva × 12

white, without legs, and with pale brown head. The skin is sparsely hairy. When full grown, the female grub is about 1/10 in. long, and that of the future male is considerably smaller.

At first the pupa (Fig. 3) is the same colour as the grub, but later becomes pale brown. The female pupa is about

Stephanoderes hampei
Fig. 3—pupa × 12

1/12 in. long, and is one and a half times the length of the male.

The Adult Beetle.—The adult female and male are of about the same size as their pupæ. Newly emerged adults are pale brown and soft; the general colour gradually changes, becoming black after 5 days. The adult beetle (Fig. 4) is of somewhat cylindrical shape, with both

Stephanoderes hampei
Fig. 4—adult × 15

ends gently rounded; its small head is situated sub-ventrally, and cannot be seen when viewed from above. The wing covers are rather shiny with longitudinal ridges and rows of minute hairs; the other part visible from above (the pronotum) is dull black with minute tubercles, pits and hairs.

Habits, etc., of Adult Beetles.—Females are much more numerous than males, the ratio being about 10 to 1. The male appears incapable of flight, and it fertilizes females of the same family in the berry where they have been produced. The female is therefore able to lay fertile eggs when it bores into a fresh berry. Newly bored berries never contain male beetles. It appears that the females do not migrate to other berries until scarcity of food in the berries where they have been bred compels them. It is not unusual therefore to find 50 or 60 females in one berry, the contents of which have, by that time, been reduced to a black powder.

The female beetle feeds for 2½ hours on a ripe berry and 4 hours on a hard green berry before it has bored a tunnel of sufficient length to contain itself completely. A full day elapses before the beetle becomes invisible externally and at least two days before the parchment cover of the seed is bored through.

The beetle may continue laying eggs over a period of 12 weeks, during which 60 or more eggs may be laid; it cannot survive more than 5 days in the absence of moisture or moist food. The life of a female beetle may extend to 16 weeks, while that of the male appears to have a maximum of 8 weeks. There are no clearly defined generations, and all stages, given suitable food, can be found at any period of the year. Observations indicate that females migrate from dried berries when the food in them has been exhausted or has become unsuitable, taking to the wing during late afternoon.

Alternative Food of Stephanoderes hampei.—In a country such as Uganda, where many species of the family Rubiaceae (including coffee) are indigenous, it might be expected that numerous alternative hosts would occur. Apart, however, from wild coffee, and a forest species of *Oxyanthus*, from the fruit of which a *Stephanoderes* species (probably *hampei*) has recently been obtained, there is only one record here of the pest occurring in other hosts: this, strangely

enough, shows that the seed of a bean —*Kayindyindi kigaga* (*Phaseolus ? lunatus*)—is at least capable of providing food for the adult beetle. (It should be added that four other species of *Stephanoderes* were found at the same time in this bean; this indicates the necessity for accurate identification of species.)

Nature of Damage Caused by the Berry-borer.—Both the adult and the grub contribute to the damage to coffee beans. The whole of a bean, or both beans in a berry, may be completely destroyed or so extensively damaged as to be of no value. Coffee showing evidence of borer attack is much reduced in market value.

An additional, and probably more serious, type of damage is caused when the female is compelled, by competition for food or by restriction of numbers of more nearly mature berries, to attack young berries the beans of which are still soft and moist. In such cases the young berries are vacated early and the injured beans rot completely; such beans after pulping will float in the wash tank, and thus the berry-borer may be responsible for "lights". These berries may continue to develop and to appear normal externally.

It has been observed that the bean tissues lining the excavations made by the insect become green after a short time. This discoloration, at one time suggested as a possible cause of "grassiness" in Uganda coffee, was proved by Leefmans in Java to be due to chlorogen acid.

Damage to properly cured coffee cannot be caused by *Stephanoderes*. The reduction of the moisture content to 13.5 per cent for *arabica* and 12.5 per cent for *robusta*, or less, prevents the adult beetle attacking coffee, and beetles die of starvation in a few days in the presence of coffee dried to this extent.

Natural Control.—Two small species of wasp-like parasites, which attack various stages of the beetle, occur in Uganda. Some account of these insects will be of interest and use.

Early in 1923 the parasite *Prorops nasuta* Waterst. was found in small numbers in borer-infested berries at Kampala. Three months later the stages of the borer present were reduced to eggs, small larvæ and adults. *Prorops* adults feed on eggs and young larvæ of the borer, and the larvæ of the parasite feed on large full-grown borer larvæ or pupæ.

The life-history of *Prorops* is as follows: The female wasp finds a berry in which the borer has been present for some time, and after stinging and paralysing larger borer grubs or pupæ lays a single egg on the ventral surface of each. In this way fresh food is ensured for the parasite larva, which hatches out after 3 days and remains on its host, sucking the body contents (Figs. 5 and 6). The larval stage is of short duration, being

Prorops nasuta

Fig. 5—young larva on borer pupa × 12
Fig. 6—young larva 24 hours later × 12

only 3 or 4 days, and when the parasite larva is full grown, the host then being reduced to an empty skin, it spins a cocoon of white silk among the debris in the berry, and pupates. The pupal stage lasts 2½ to 3 weeks, after which the parasite, now adult, bites a hole through

the cocoon and emerges. The total period occupied by the immature stages—egg to emergence of adult—is 3½ to 4 weeks. A further 2½ weeks elapse before the adult parasite begins to lay eggs; these may be laid without fertilization by a male, but in such instances the resultant progeny are all males. The rate of egg-laying in captivity varied between two per day and one every two days, while the maximum number laid by one female was 37. The maximum length of life of a female was 65 days.

The various stages of *Prorops* are described below to assist their recognition.

The adult (Fig. 7) is about 1/10 in. long, not including the antennæ (feelers). The head and body are dark brown (almost black), while the antennæ and legs are pale brown. The antennæ of the female are short, rather thick, and with

Prorops nasuta
Fig. 7—adult female parasite × 15

twelve segments, the first of which is short and hidden under the head. The jaws are strongly developed and over them is a short snout-like projection. The ovipositor of the female is not usually visible except when in use.

The egg (Fig. 8) is sausage-shaped and comparatively large (about two-thirds the size of that of *Stephanoderes*); it can be seen by the unaided eye, but with difficulty because its colour is identical with that of the host. The larva (Fig. 9) likewise resembles the host in colour; it is very faintly segmented and without legs or hairs. The full-grown larva is rather

Prorops nasuta
Fig. 8—egg × 24

less than 1/16 in. long; the head is at the blunt extremity.

The second species of parasite is *Heterospilus coffeicola* Schmied. It was first found in 1923, and later that year

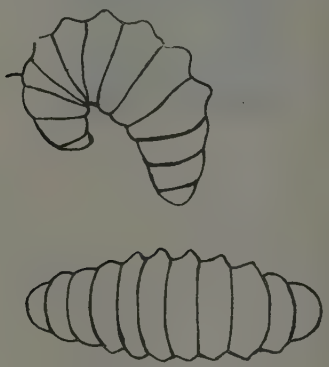
Prorops nasuta
Fig. 9—full-grown larva × 15

gradually replaced *Prorops* and continued to control the borer. The adult wasp, in contrast to *Prorops*, appears to spend little time within the berry. In no instance has more than one egg, larva or cocoon of *Heterospilus* been found in one coffee berry. The egg (Fig. 10) is minute (about 1/64 in. long), and, owing to its colour resembling that of borer eggs, careful

Heterospilus coffeicola
Fig. 10—egg × 20

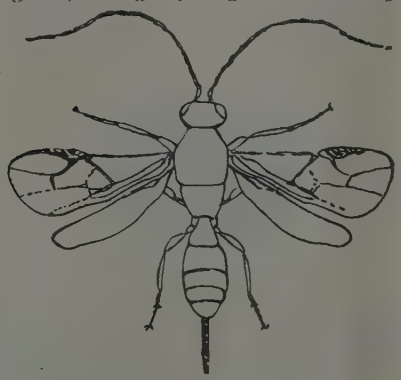
search aided by a lens is necessary to find it. The parasite egg is laid, probably without the adult entering the berry, among a cluster of borer eggs in a newly bored berry. On hatching, the larva feeds

on eggs (mainly) and larvæ of the borer, sucking out their contents, and it may dispose of fifteen or more eggs and larvæ during its larval period of about 20 days. The full-grown larva (Fig. 11) is about the same size as that of *Prorops* and of



Heterospilus coffeicola
Fig. 11—larva (lateral and dorsal views) × 15

similar appearance, but it may be distinguished from the *Prorops* larva by the presence of sparse minute hairs and its paired, segmental, well-developed dorso-lateral prominences. A cocoon of white silk, situated close to the entrance of the bore-hole, is spun by the full-grown larva prior to pupation. The adult female (Fig. 12) is slightly larger than *Prorops*,



Heterospilus coffeicola
Fig. 12—adult female × 12

from which it may be easily distinguished by the long slender antennæ, the small dark patch on the front border of the fore wing, and the long ovipositor projecting from the end of the abdomen. The body and the antennæ, except near the base, are dark brown (almost black), while the legs, ovipositor and first four antennal segments are pale brown. The male, although similar to the female, has no ovipositor and has a small dark patch (stigma) in the front border of the hind wing.

The two parasite species have considerably different habits. *Prorops* spends most of its life within the berry; it is most common in old, over-ripe berries, in which twenty or more in some stage of development may be present, is never found in green berries, is easily propagated and transported. *Heterospilus* appears not to enter the berry; it occurs singly, and usually in partially ripe or ripe berries only, and can be propagated only with some difficulty. The indications are that *Heterospilus* is considerably more useful than the other species, because it attacks the beetle quite early after a berry is bored and each larva destroys numerous very young stages of the borer.

In Uganda *Prorops* parasites have been successfully introduced from Kampala into Bwamba County (on the entrance western border), and this introduction has resulted in a great reduction of the previously intense infestation of *Stephanoderes*

Factors Encouraging Stephanoderes.—The influence of altitude has already been mentioned. In what way this affects the beetle is not known, but the same phenomenon has been observed in Java.

The shading of coffee berries, either by overhead shade or by dense foliage of the coffee trees themselves, is distinctly favourable to the berry-borer. In this

case, however, it appears that the influence is indirect, by making the habitat less suitable for the parasites. Instances have occurred where estates or parts of estates under heavy shade have suffered intense borer damage continuously, and thinning or complete removal of shade has greatly reduced the incidence of the pest. Of a similar nature are instances where pruned trees have suffered little damage in comparison with unpruned, densely foliaged trees growing in the same locality. Again, large natural trees, providing dense shade, left growing in coffee have been proved to be centres of infestation; the further away from such trees the coffee, the less intense the infestation, until at 50 yards distance the borer could scarcely be found.

The culture of small blocks of *robusta* alongside similar blocks of *arabica* trees appears to have considerable influence in keeping down the infestation by borer. The *robusta* produces many small flowerings, and consequently has at most periods a series of different aged berries which may, in conjunction with the *arabica,* provide conditions more favourable to the maintenance of the parasite population. It must, however, be added that *large* blocks of the two coffee species are liable to intense attack, just as are pure stands of either species.

The dense, matted growth of large, closely planted, unpruned coffee trees is favourable to intense attack by borer.

Control of Stephanoderes.—As previously mentioned, the mode of life of the pest is such that it is protected during almost the whole of its existence. The time when the beetle is possibly controllable by stomach poisons is restricted to when it begins boring into fresh berries; the small area of skin removed by the beetle in beginning the bore, and the fact that this is scraped away and falls as dust (i.e. is not eaten), reduce almost to vanishing point the possibility of giving the beetle a lethal dose of an arsenical or other stomach poison by means of spraying.

The possible value of application of contact poisons likewise is extremely limited, because the beetles must be caught in the act of starting the bore. Only a minute fraction of the beetle population would, at any one time, be vulnerable, and even daily sprayings could not achieve any marked reduction; in addition, the cost would be prohibitive.

A further possible chemical method of control for consideration is that of fumigation of every tree by means of prussic acid gas (in some form) under cover of small tents. This is a method successfully applied in some countries for control of insects, particularly scale, on citrus trees. In this case the trees are large and less numerous, and the value of the crop per tree must exceed enormously that of a coffee tree in order to make the expenditure on fumigation an economic possibility. Again, in the case of citrus trees, comparatively immobile insects are involved as against one which flies freely; this consideration and the enormous number of trees in the case of coffee involve a time factor which would, probably to a considerable degree, reduce the value of fumigation. It seems therefore that fumigation is not practicable in the case of coffee trees.

Before passing on to the consideration of other possible methods of reducing damage by *Stephanoderes,* it is desirable to point out that two, if not all, of the chemical methods discussed above would have at least some adverse effect on the borer parasite population, and that even if similar chemical methods were found to be successful and practicable from the point of view of expense, the adoption of such measures would possibly make it

necessary to apply them continuously: the help from parasites would be seriously reduced or eliminated. It should be added that in Java, where the pest occurs as an introduction and without the parasites, a great variety of chemical methods of control, including spraying with rubber latex, have been tried without evolving any practicable method.

When dealing with insects affecting crops, and especially when the crops are grown by natives or others with very limited resources, the writer believes that the possibilities of cultural methods of control should receive first consideration.

It has been stated earlier in this article that the parasites are capable, under suitable conditions and for considerable periods, of reducing the population of borers to negligible proportions. Unfortunately, as is often the case with parasitic control, periods occur when, owing to lack of hosts or to other adverse circumstances, the parasites become greatly reduced in numbers (almost to complete absence), and the borer then multiplies freely and may eventually attack 80 per cent or more of the berries present on the trees. A restricted part only or the whole of a coffee estate may be affected. Where the borer attack is intense and the parasites prove, by careful examination of adequate samples of berries, to be few or apparently non-existent, it may be advisable to strip a small crop in order to protect the succeeding main crop. This is a drastic measure, and one which the writer rarely advocates, since it involves a certain loss of crop and the cost of stripping. (It should be noted here that a similar measure, that of keeping the trees completely free from berries for six months each year, is employed both in Brazil and Java.) Such strippings should where possible be heated immediately in an artificial drier to kill the beetles, and some return may be obtained by sale of the *buni*.

A possible alternative to this drastic action where borer attack is less intense, but under otherwise similar circumstances, is the collection of all bored berries, including those which may have fallen, and their storage in shallow trays within a roofed gauze-walled chamber (or in gauze-covered trays in an open shelter), to allow such parasites as may be present to escape without the beetle. This necessitates the use of gauze with fine wire strands, 40 to 44 to the inch, and well-fitting joints. The cost of the apparatus, in view of the present prices of Uganda coffee, has been stated to be prohibitive.

Action against *Stephanoderes* in Uganda is therefore in most instances limited to making conditions favourable for its parasites, i.e. by restricting or eliminating overhead shade and by maintaining open growth of the coffee trees themselves.

In normal circumstances, when borer incidence is low, it is advocated that fallen overripe berries should be left, because they constitute the main reservoir of *Prorops* parasites.

Progress Report on Elgon Dieback of Coffee

By C. A. THOROLD, *M.A., A.I.C.T.A., Mycologist, Kenya.*

"Elgon Dieback" is particularly prevalent in coffee farms on the slopes of Mount Elgon, but may also occur in other districts. For want of a better, this name is retained for the present, and is preferable to the use of the term "anthracnose". It will be shown later that "anthracnose" fungi are not characteristically associated with this disease.

SYMPTOMS.

Almost any leafy portion of the tree may be affected. The branch wilts and later turns brown and black. The wilt is of varying severity. Only a small secondary or tertiary may be affected or, at the other extreme, a whole sucker or a large part of the top tree may suffer. Most usually a primary branch is in whole or part affected. Subsequent to the first wilting stage, the damage spreads slowly as a dieback which usually ceases at a main junction, e.g. where a primary joins the main stem. At particular seasons a certain amount of blackening accompanies the earliest visible stage of the disease. One or more nodes or internodes may be discoloured, and there is also typically a blackening of the base of the leaf, where the petiole joins the lamina. It is difficult to describe the symptoms accurately and comprehensively; they vary from tree to tree and at different times of the year.

PRESENCE OF FUNGI.

Representatives of several genera have been obtained in cultures of Elgon dieback material. Species of the following parasitic genera have been noted:—

Phoma (frequent).
Phomopsis.
Diplodia (infrequent).
Colletotrichum (only rarely present).
? *Sphaeropsis.*

Saprophytic or weakly parasitic fungi have been isolated from what appeared to be quite early stages of the disease: *Nigrospora* and *Epicoccum* are examples. Bacteria have been present in certain cases, but not invariably.

Inoculations with pure cultures of the more commonly occurring fungi and bacteria have been carried out. The symptoms of Elgon dieback have not been reproduced in controls or inoculated shoots, even when accompanied by wounding.

Small has described types of coffee dieback in Uganda. One, which he refers to as "small scale dieback", appears to resemble what is here described as Elgon dieback; rarely "the appearance is that of a tree scorched by a bush fire". This appearance is often noted in Kenya. A species of *Phoma* has been frequently found associated with coffee dieback in Uganda, and a species of *Phomopsis* is also recorded. Small carried out a number of inoculations with the *Phoma* but, out of a total of sixty, all were negative except one. A species of *Phoma* had been found on coffee in Kenya by Dowson in 1917. This fungus was particularly associated with trees believed to have been damaged by lightning.

It is conceivable that the reproduction of the disease by artificial inoculation has failed for either of the following reasons: (*a*) the parasitic fungus has not yet been isolated and cultured; or (*b*) certain specific conditions which should accompany inoculation have not been fulfilled. The writer inclines to the view that the disease is essentially physiological, and that no parasitic fungus or other organism is primarily responsible. Circumstantial evidence in support of this

belief is provided by observations which have been kept for the presence of dieback on a number of trees. In certain plots and border rows surrounding them any dieback shoots are pruned off at frequent intervals. In other plots and "surround-rows" the affected branches are allowed to remain. There is no apparent difference in the amount of dieback noted under these two treatments. The disease is certainly no more severe where what might constitute a constant source of infective material is maintained.

CONDITIONS UNDER WHICH ELGON DIEBACK OCCURS.

The disease is most prevalent on exposed slopes as opposed to plantations in sheltered valleys. In a general way, it may be said that in this district, where coffee berry disease occurs, Elgon dieback is infrequent or absent. The conditions required for the optimum development of these two diseases are directly opposed. When coffee berry disease and Elgon dieback are present together, it appears that neither is at its maximum. Local conditions vary from year to year, and where Elgon dieback may be serious and present to the exclusion of coffee berry disease in one season, the position may be reversed at another time, or else both coffee berry disease and Elgon dieback may be present to a slight extent.

There is no indication that Elgon dieback is to be associated with shallow or infertile soil. The disease occurs on vigorous trees in relatively good health. The worst feature of Elgon dieback occurs on trees already debilitated. The loss of suckers and primaries may then seriously affect the yield of the tree. As the result of recording yields and amount of dieback at Kapretwa in 1934-35 season, there was found to be no obvious correlation between Elgon dieback and yield. Trees which were noted as having a large number of affected shoots did not necessarily give a lower yield than trees with less Elgon dieback.

PREVENTION OF ELGON DIEBACK.

Shade.—Observations have so far indicated that with sufficient tree shade little or no Elgon dieback occurs. This would presumably also apply for artificial shade, but it has not been possible to make observations on Elgon dieback under other conditions of shade. However, an overhead canopy is being erected on two acres of coffee at Kapretwa in an area where Elgon dieback is prevalent. Since preliminary observations will have been made over at least twenty months before shading, it will be possible to make exact observations on the reduction of dieback due to artificial shade. There is a general prejudice against the use of tree shade in this district. It is therefore necessary to study the question thoroughly before advocating the general planting of shade trees. Whilst this apparently obvious solution of the Elgon dieback problem is open to the protagonists of shaded coffee, it is realized that the advantages of lessened dieback under shade might be offset by increase in other diseases, but there is little evidence of this from the few shaded plantations on farms in this district. In order to meet the objections put forward, it is necessary to prove that coffee under tree shade is economic. An experiment is now being laid down on Messrs. Anderson Bros.' farm to compare the yields of shaded *versus* unshaded coffee, and at the same time to make a comparison of the merits of about six different shade trees. No results of value can be expected from this experiment under about 5-10 years hence.

Varietal Resistance to Elgon Dieback.—Observations have been made on about 300 individual trees for the occurrence of dieback since November,

1934. It is now possible to say that a number of trees are resistant, and possibly immune, to Elgon dieback. In particular, a copper-tip type occurring in French Mission coffee is notable in this respect. It is estimated that this type is present to the extent of about 10 per cent of the trees of this variety. It seems in other respects admirably suited to the conditions of the district, except for the quality of the coffee. A high proportion of elephant beans seems to be present in the coffee from this type of tree. It is hoped that it may be possible to select one or more trees not possessing this disadvantage.

At the moment there appear to be only two alternatives for the control of Elgon dieback: —

(*a*) To grow only the resistant type of coffee tree, with concomitant loss of quality in the coffee.

(*b*) To grow coffee under shade. Good quality coffee is assured, but with the tree shade the crop may be reduced through other diseases or insufficient moisture at certain seasons on account of loss due to absorption by the shade trees.

These two alternatives can confidently be recommended to the farmer, but it must be realized that there has not yet been time to subject them to rigorous proof and scientific study. The employment of tree shade entails a host of complicating factors, all of which vary locally. The appearance of other diseases and the possibility of the coffee being "droughted" in some localities must be considered and in particular need further investigation. As regards the use of resistant types, this obviously needs careful study, so that any future replanting shall be done with a type that resists Elgon dieback, and, at the same time, meets as far as possible the agronomic, economic and commercial requirements.

The following experimental and observational work is being carried out, or is planned for the future: —

(1) Dieback observations are made on a large number of individual trees. This gives (*a*) general information on the seasonal prevalence of the disease, and (*b*) indication of trees which are consistently free from Elgon dieback.

(2) The yield of 116 individual trees is combined with dieback observations. These crop records also serve as a "uniformity trial" carried out for two seasons previous to the erection of artificial shade. These crop records will continue, as also on unshaded coffee for comparison. From these records it is hoped to select trees which combine consistent high yields with resistance to Elgon dieback.

(3) Comparison of trees in plots where dieback is pruned off and left on respectively. These plots are also in the nature of a uniformity trial (for susceptibility to Elgon dieback), and can conveniently be converted later to experiments on the effects of particular treatments on Elgon dieback, e.g. mulching, fertilizing.

(4) Tree shade plots are now being planted. Their purpose and scope have been described above.

(5) Propagation.—Trees selected for resistance to Elgon dieback, whether or not combined with crop records, are being propagated from selfed seed and vegetatively by rooting of suckers, and in a few cases by cuttings.

(6) Grafting.—Cleft and crown grafting on to suckers are being employed for the following purposes: —

(*a*) To determine (i) whether resistance to Elgon dieback is maintained by scions from resistant trees on susceptible stock, and (ii) whether susceptible scions on susceptible or resistant stock remain susceptible.

(*b*) If these suppositions are true, then

grafting will be an excellent way of testing the resistance of various types of coffee. It may also happen that a tree is only apparently or fortuitously resistant; therefore, when grafted on to a susceptible tree, its true nature would be ascertained.

(*c*) It is possible that grafting might have uses on a larger scale for the reduction of loss of crop due to dieback, and in the interval before other control measures against Elgon dieback had become effective.

(*d*) By inarching or grafting it is possible theoretically to bring a young plant into bearing sooner than on its own roots. This method of propagation will be employed in the production and multiplication of desirable types and typical selections. The method of "approach-grafting" can obviously be used for seedling and vegetatively propagated clones. Inarching has already been found to be an easier and more certain method of grafting than that in which only the stock is rooted whilst union is being attained. These methods are being employed to test the resistance of various varieties, e.g. Series A, Harar, Plateau Bronze, and Blue Mountain.

(7) Routine measurements are being made of root, shoot and leaf growth, combined with soil temperature observations.

(8) It is intended in the future to make observations on other climatic and soil factors. At the moment it is not possible, nor even particularly desirable, to accumulate a large amount of such data indiscriminately. In time it will be possible to select the particular "elements" required in connection with the study of Elgon dieback.

(9) Mineral requirements of coffee trees and the possibility of deficiency will be investigated in the future. To carry out such a study, it is desirable to have uniform material to work with, preferably vegetatively propagated. It is intended that the injection method, as used at East Malling, shall be applied to coffee.

It will be seen from the above programme of work that the investigation of Elgon dieback is regarded as merely a part of the wider problem of successful coffee culture in this district. This naturally involves a study of the parasitic and other fungi associated with the crop. The problem is pathological rather than strictly and solely mycological.

REFERENCES.

W. Small.—Dieback of *Coffea arabica* in Uganda: Uganda Protectorate Dept. Agric. Circ. No. 4, 1920.

W. Small.—Notes on Species of *Colletotrichum* and *Phoma* in Uganda: Kew Bulletin, pp. 57-67, 1921.

W. J. Dowson.—A New Disease of Coffee: Dept. Agric., B.E.A., Div. of Mycology, Leaflet 1, 1917.

Maize Silage in East Africa: Its Preparation, Quality and Feeding Value

By M. H. FRENCH, *M.A., Dip. Agric. (Cantab.), and* J. T. PURVIS, *B.Sc. (Agric.),*
Department of Veterinary Science and Animal Husbandry,
Tanganyika Territory.

EXPERIENCE IN SILAGE PRODUCTION AT MPWAPWA.

Maize has proved itself throughout the world as the crop best suited for silage production. Therefore, when this Department first decided to make silage, some twelve years ago, maize was naturally chosen as the crop to be ensiled. The method of ensilage adopted was to stack the maize into rectangular pits, ten feet square and twelve feet deep. It was assumed that the best results would be obtained if the methods used in other countries were adopted.

The first yields of silage were disappointing because the crop was too mature at the time of reaping. Cobs with hard glazed grains had already formed and the bases of the stems had become very fibrous. Improvements were made in subsequent years, and in 1931 the crop was being cut at the "milky" stage and ensiled without wilting. Even then the bases of the stalks were so hard that many were inedible and caused much wastage through falling under the feet of the cattle. Every morning in the dry season, uneaten portions of the maize stalks and also edible portions, which had become soiled with manure through falling from the mangers, were being carted out of the *bomas.*

In 1932 an experiment was designed to test out different methods of ensiling the crop. The crop was allowed to reach the same stage of maturity as in the previous years. Besides the farm silage made in pits, a small experimental pit silo was used. Analysis and digestibility experiments were carried out on the different products, and the details of the experiments were published in 1932. (1)

The main conclusions reached were that—

(i) The best silage is obtained when the crop is chaffed prior to ensilage.

(ii) If ensiled in the long state into the pits, and then fed directly to the stock, about one-third of the silage is inedible, and still further quantities are wasted by trampling under foot.

(iii) If cut into 18 in. lengths before feeding to the stock, there is less wastage and a greater proportion eaten.

It was suggested that the best method to use in up-country stations is to ensile the green crop by pressing lengthwise into a clamp, over which the wagons can be drawn to help in consolidating the crop, and to cut out small lengths with a hay knife as required for feeding.

This suggestion was carried out in 1934, and a clamp was made in the ground, 110 ft. long at ground level, 14 ft. 6 in. wide, and 8 ft. 6 in. deep. The two ends sloped downwards to leave a flat bottom to the clamp, 35 ft. long. The walls of the clamp were vertical, to allow the maize to settle down evenly when filling was finished.

Although the "milky" stage is usually regarded as the best stage at which to cut maize for ensilage, the previous experience at Mpwapwa has suggested that the bases of the stalks become too fibrous and too hard for the stock to deal with. In this district there is generally a short

drought period in the growing season, and the maize crop is often stunted and thin. The usual rate of seeding adopted here is 15 lb. of maize per acre. At this distance there is ample space for stem development. It was, however, decided to try a heavier rate of planting and so get thinner and softer stems. This was entirely successful, and together with earlier cutting and the clamp method of stacking the best silage ever made at Mpwapwa was produced.

The crop was ensiled so successfully and the quality of the product was so good that farmers would be well advised to follow the same general procedure as that adopted in 1934 at Mpwapwa. Climatic and soil conditions vary considerably of course with locality, but the Mpwapwa method will still apply, with only small modifications in the cultivation dates and the interval required to reach the right stage of maturity. The details of the cultivation, planting and reaping of the maize crop are as follows:

Cultivation, Planting, Reaping and Ensiling Details.

The maize crop was grown on a 25-acre field which had been under cowpeas the previous year and dressed with kraal manure. The soil was patchy, and varied from a poor sand to a light loam. On the whole, it could be considered in good "heart" and fairly clean, because all thorns and strong weeds had been removed during the winter.

Heavy rains after the 6th January enabled ploughing to commence on the 12th, and using two 2-furrow ox ploughs and one 3-furrow tractor plough the 25 acres were completed in six days. Owing to the friable nature of the soil, a single harrowing produced a deep tilth. This harrowing was done immediately in front of the maize planter, to avoid loss of time whilst the weather was unsettled.

A fairly heavy seeding of 30 lb. of maize per acre was given, as this amount produces plants with thin stems but with the same quantity of foliage as is formed when the plants are wider apart. The maize was drilled in rows 36 in. apart, to enable the crop to be cultivated later. Planting began on 17th January, and, after many interruptions due to rain, was finished on the 26th.

Germination was good and regular, and the crop got a good start. Later, a fourteen days' drought in February considerably retarded growth, especially on the poorer sandy spots.

Small cultivators were used to loosen the soil, check weeds, and to guard against excessive "run-off" during the expected heavy rains. After this single cultivation, small ridges were thrown up on the roots of the crop. As the crop had been drilled roughly in the line of the contours, these rows provided a big check to the run-off caused by the heavy storms during the later stages of growth.

Reaping commenced on 30th March, i.e. 73 days after planting. At this time the cobs were nicely formed (in the milky stage) on the more advanced plants but about 50 per cent of the crop was still in the flowering stage. There was abundant leaf on all plants, the stems were still soft and full of sap, whilst yellowing of the stem bases was only observed on a few very advanced plants.

The maize was cut by hand, gathered at once into heaps, and carted away with as little loss of time as possible. Wilting was prevented by cutting only as much as could be carted away immediately. The silage was packed lengthways in the pit, the incoming loaded wagons pressing and consolidating the previous loads. The pit was filled to a height of about 3 ft. above ground level, to allow for further settlement.

A thin covering of hay was first

spread over the maize, and the whole covered with a layer of soil 2-3 ft. deep, and well trodden down. A rounded finish was given to the top of the pit, and small drains dug at the side to take away rain water.

Quality of Clamp Silage.

When the clamp was opened in August the covering from one end was removed, and a slice of silage about 9 in. thick was cut off the end. As more silage was required, further slices were cut off with a hay knife. By this method the minimum quantity of silage is exposed, and less wastage results.

The silage produced was practically as green as the maize when ensiled. It possessed no unpleasant odour, was relished by all classes of stock, and, of more importance, every scrap was eaten. There were no inedible portions to cart away, and because it was in short lengths the stock did not pull it out of the mangers and drop it under their feet. All previous silage made on the farm has been of the "light brown acid" type, but this year it was of the "green fruity" type. Experiments at Cambridge have proved that this latter type is the most palatable and most nutritious form that can be produced from any given crop. Slight wastage through spoiling round the edges of a silage pit can hardly be avoided, yet in the 1934 clamp very little spoiling took place.

In 1935, the same pit was used again, but the maize was planted at the old and more usual rate of 15 lb. per acre. The crop grew well, and reached the correct stage of maturity in about 20 days, as in the 1934 season. It was, however, allowed to develop further and reach the milky stage before being cut and ensiled. The carting to and filling of the pit were done exactly as in 1934. As a result the silage produced this year was not quite so green as when the less mature crop was ensiled. It was, in fact, midway between typical "acid brown" and "green fruity" silage. This crop is now being fed and the stock are not consuming it completely, all the harder portions at the base of the stem being left and trampled underfoot.

This 1935 silage emphasizes the necessity for ensiling the maize before the stems dry off or lignify at the base, i.e. at the flowering stage. It also lends much more support to the conclusions reached in 1934, which were—

(*a*) to plant the maize closely, so as to get a large leaf development with thin succulent stems; and

(*b*) to ensile the crop earlier than is usually recommended.

In this connection we might mention that the most suitable plot of maize for ensilage that we have ever seen was maize ploughed in at the rate of 60 lb. per acre. However, seeding at the rate of 30 lb. per acre will provide the farmer with a good type of fodder for ensiling.

Nutritive Value of Maize Silage.

Feeding trials have been carried out during the past three years to determine the composition, digestibility and feeding values of the various types of silage made at Mpwapwa. (2) The experimental animals have in all cases been either native sheep or local zebu cattle. The digestibility and nutritive values thus apply strictly to East African conditions, and have not been calculated by the assumption of European or American figures. All analyses have been recorded on a SiO_2-free dry matter basis, because the amount of soil contamination will vary considerably with local conditions, and even in samples from different parts of the same clamp.

Typical analyses showing the composition of silage made at Mpwapwa are given in Table I, and are compared with average English and American figures.

TABLE I

COMPOSITION OF MAIZE SILAGE (SiO2-FREE DRY MATTER BASIS)

	TANGANYIKA SILAGE			(3) ENGLISH SILAGE	(4) AMERICAN SILAGE
	Made in clamp	Made in pit	Made in pit after chaffing	Made in Silo Tower	Made in Silo Tower
Crude Protein ..	7·45	6·20	6·54	11·09	9·05
Ether Extract ..	1·93	2·35	3·26	5·64	2·86
N-free Extract ..	53·00	52·71	53·26	53·98	53·81
Crude Fibre	31·43	31·88	31·90	23·32	27·62
Soluble Ash	6·19	6·85	5·03	5·97	6·66

The digestible nutrients and feeding values of these different types of silage are presented in Table II. The silage made from the less mature crop is digested most easily. This is true particularly of the protein and fibrous fractions, and is probably due to the immaturity of the crop.

TABLE II

DIGESTIBLE NUTRIENTS AND STARCH EQUIVALENT VALUES IN 100 PARTS OF SiO2-FREE DRY MATTER

	SILAGE FROM UNCHAFFED MAIZE		SILAGE FROM CHAFFED MAIZE		
STAGE OF MATURITY	Cut from clamp in 9 inch lengths	Made in pit and fed in 18 inch lengths	Mpwapwa	English	American
	Flowering	Cobs in milky stage	Cobs in milky stage	Cobs in milky stage	Cobs glazed
Digestible Crude Protein ..	2·61	1·16	2·36	7·26	4·81
Digestible Ether Extract ...	1·34	1·48	2·56	5·02	2·05
Digestible N-free Extract ..	39·59	28·24	32·90	37·72	35·52
Digestible Crude Fibre	22·55	13·77	20·16	16·40	18·76
Digestible Organic Matter.. ..	66·09	44·65	57·98	66·40	61·14
Starch Equivalent	55·06	37·60	49·34	57·90	51·50
Nutritive Ratio..	1:25	1:39	1:26	1:9	1:12

The silage from the less mature crop made in the clamp thus possesses a feeding value equal to that of American and English maize silage and superior to any other made at Mpwapwa. The results show that under the semi-arid conditions common to so much of East Africa there is a large increase in the feeding value of silage if the maize is cut before reaching the stage of maturity considered necessary in many other parts of the world.

Losses during Ensilage.

The loss of dry matter during the ensilage of maize has been worked out from each type of silage, and the results are tabulated in Table III.

TABLE III

LOSS OF DRY MATTER DURING ENSILAGE

YEAR	Type of silo	Maturity of maize	Maize ensiled	Type of silage	Loss of dry matter
1932..	Rectangular pit	Cobs "milky"	Whole	Acid light brown	12·17%
1932..	Circular pit	Cobs "milky"	Chaffed	Green fruity	10·81%
1934..	Clamp	Flowering	Whole	Green fruity	9·41%

From his results at Cambridge, Woodman states that "the loss of dry matter, when green fruity silage is made, amounts, under favourable conditions, to about 9 per cent." The losses in producing green fruity maize silage at Mpwapwa are similar to those encountered in other parts of the world.

Weight of Silage in Clamp.

If a clamp of the type employed at Mpwapwa is used, the weight of silage contained can be calculated with reasonable accuracy. When settling has ceased, the average weight per cubic foot was found to be 35 lb. of silage, with a dry matter content of 21 per cent.

Yield of Silage per Acre.

The weight of silage produced per acre varies with locality, soil fertility, climate, etc., but under the hard Mpwapwa conditions a yield of 5.4 tons per acre was obtained.

(*Continued on page* 235)

A Further Note on Rhodes Grass

By D. C. EDWARDS, *B.Sc. (Wales), Agricultural Officer, Kenya.*

Since the publication about a year ago of a preliminary note on this grass (*see* Leaflet, "Rhodes Grass for Pasture and Hay", 1934, Department of Agriculture), further experience has been gained, and it is desired to place some of the more important facts of this experience at the disposal of farmers.

At the outset it can be stated that the Australian strain of Rhodes grass—that is, a grass of African origin which was introduced into Queensland—has continued to give very satisfactory results, and that there is every reason to suppose that it is well suited for hay production and the sowing down of pastures over a wide range of climatic and soil conditions in Kenya.

Persistence.—Plots of the grass have been in use for seed production for the past three years, and, since the cleaning which was carried out in the early stages of establishment, practically no weeding has been necessary. The ground is densely covered and the plots have remained pure.

Hay Yields and Value for Grazing.—Experiments on a fairly large scale have shown that yields of from three to four tons of hay per acre can be expected under average conditions in the Nairobi district. Furthermore, four cuts per year have been obtained on plots at Kabete.

Under the exceptionally dry conditions of the past year, a paddock of the grass at the Scott Agricultural Laboratories provided useful grazing throughout the dry season. On the Veterinary Training Centre farm at Ngong the grass has also shown itself superior to the natural herbage for dry season grazing. At this centre an experiment is in progress to compare the effects upon the milk yields of two groups of cows of Rhodes grass pasture and natural pasture.

Seed Production.—It has been shown that good crops of seed of this grass can be obtained in Kenya. When manured especially for seed production, a yield of 50 lb. was obtained from a 1/5 acre plot, and a yield of about 200 lb. per acre should be obtainable under ordinary circumstances.

In connection with seed production an important fact has come to light. This is that Rhodes grass seed requires a rather long period of "after ripening". A series of tests have shown that seed stored for a period of over two years has continued to improve in germinating capacity, and that it is advisable in every case to use seed at least one year old. This information is obviously important, both in the production of home-grown seed and in the importation of seed from Queensland.

Rhodes Grass in Mixtures.—Experiments have been conducted primarily with the object of finding a suitable leguminous plant to grow in mixtures with this grass. Amongst a considerable number tried, an indigenous plant obtained from the Machakos area has given the most promise. This is *Indigofera tettensis.* This plant has been grown with Rhodes grass, and has produced a hay containing a good proportion of the legume without any marked reduction in the yield of the crop as a whole being evident.

One of the difficulties in the selection of a suitable leguminous plant appears to be the relative rates of growth of the seedlings of the grass and the legume during the early stages of establishment. In many cases, such as when a fairly high proportion of lucerne is included in the mixture, for instance, the rapidly developing seedlings of the legume suppress the Rhodes grass to a very considerable extent, and result in a much reduced yield of hay, while in other cases the grass suppresses the legume, and, although the yield of hay may not be affected, it is found that the legume has practically disappeared. *Indigofera tettensis* is capable of growing with Rhodes grass without either of these undesirable results.

It is not surprising that *Indigofera* and Rhodes grass are capable of growing successfully together, as the plant is found associated naturally with this grass in some parts of Kenya.

It has been shown that *Indigofera* is palatable in the hay and is non-toxic. Another very important consideration is the fact that it is capable of producing heavy yields of seed. It is desirable to obtain further information on the possibilities of this plant before an attempt is made to produce considerable quantities of seed, and as the work progresses it is likely that other legumes will prove of value for mixtures, such as small proportions of pasture types of lucerne.

Response to Manures.—Rhodes grass responds to mineral fertilizers and can be stimulated considerably by dressings of ammonium sulphate. On most soils in Kenya, however, the most important requirement appears to be a plentiful supply of organic manure. The most convenient and effective way of providing this is by night herding animals in *bomas* over the area intended for the paddock before the preparation of the land for sowing is undertaken.

Place of Rhodes Grass in Stock Farming.—Although Rhodes grass is adapted to a wide variety of climatic and soil conditions, its uses in different parts of the country will vary.

In areas at comparatively high altitudes (from 6,500 feet to 10,000 feet*), with a well distributed rainfall of 40 in. per annum or more, where Kikuyu grass pastures can be maintained, the chief use of Rhodes grass will be as a hay crop. Under these conditions the production of hay is an important consideration, and, apart from the value as a reserve, its use should do much to counteract the undesirable effects produced by rapidly growing Kikuyu grass at certain times of year.

In areas of intermediate conditions, where the rainfall is sufficient to permit of intensive management but where Kikuyu grass does not form a part of the natural vegetation and cannot be successfully cultivated owing to the higher temperatures which are experienced, Rhodes grass can be used both for pastures and hay. Under these conditions it is probable that it will prove particularly valuable for sowing down land which has previously been devoted to maize-growing, especially when suitable mixtures of the grass with leguminous plants have been produced.

In the drier parts of the country the provision of a reserve supply of fodder

* Successful trials have not yet been made above an altitude of 8,000 feet.

for use in drought periods is an essential part of stock farming. Rhodes grass is well suited to the production of hay in these areas. On properly prepared land a heavy crop of leafy hay should be procurable in four months from sowing and, in addition to short periods of grazing, a crop should be available every rainy season for a considerable number of years, provided the soil fertility is maintained by supplying farmyard manure.

The Possibility of a Supply of Cheap Seed.—One of the obstacles to the more general use of this grass in Kenya is the somewhat high price of the seed. The present price is Sh. 1/40 per lb. From the experience gained at Kabete and at the Scott Agricultural Laboratories there appears to be no reason why the price should remain high. Good seed has been obtained for a succession of seasons at these centres and, as has already been stated, heavy crops can be produced. It is suggested that a number of farmers might take up seed production of Rhodes grass and so make available a supply of cheaper seed. An export trade may even be developed, as the supply from Queensland is limited. Until this cheap supply is forthcoming, much can be done to extend the grass by setting aside a comparatively small plot for seed production.

Conclusion.—Work has been conducted over the past five years with the object of finding pasture and hay types suited to the conditions of the areas of better rainfall which are outside the potential Kikuyu grass districts. It is believed that this strain of Rhodes grass will go far to fulfil the requirements of these areas, and will play an important part in the more intensive farming methods of the future, towards which there is already a movement.

Maize Silage in East Africa : etc.

(*Continued from page* 232)

Summary.

Any settler can produce a large quantity of highly nutritious green fruity silage if he follows the experience gained at Mpwapwa. The details from the planting of the crop to the filling of the clamp are presented. The loss during ensilage in East Africa is not greater than in other parts of the world.

The feeding value and yield per acre of silage have been determined for semi-arid conditions on a poor soil.

REFERENCES.

(1) French.—Ann. Rept. Dept. of Vety. Sci. and An. Husb., Tanganyika Territory, 1932, p. 48.
(2) French.—Ann. Rept. Dept. of Vety. Sci. and An. Husb., Tanganyika Territory, 1934, p. 86.
(3) Woodman and Amos.—J. Agric. Sci. 8 (1928), 194.
(4) Henry and Morrison.—Feeds and Feeding, 9th Edn.

Preliminary Notes on the Soil Erosion Demonstration at the Coffee Research Station, Lyamungu, Moshi

By the Staff.

The demonstration consists of a series of eight adjacent plots, each 100 feet (down the slope) by 14 feet 9 inches, or approximately one-thirtieth of an acre, on a uniform slope of 1 in 6. The land was in heavy (probably virgin) bush up to March, 1934.

The plots are separated along their length and closed at the top by concrete blocks sunk into the soil and protruding 3 to 4 inches above the general soil surface. At the bottom of each plot there is a concrete tank, in which the eroded soil and run-off water are collected.

The treatments, which were commenced on 21st March, 1934, and may be considered to have been effective by 1st February, 1935, are as follows:—

Plot 1.—Control.
Plot 2.—Contour hedge on bund.
Plot 3.—Control.
Plot 4.—Contour hedge on bund and procumbent cover crop.
Plot 5.—Control.
Plot 6.—Cover crop (procumbent).
Plot 7.—Mixed cover crop (erect).
Plot 8.—Control.

All plots were planted with coffee at a spacing of 9 feet by 9 feet on 30th April, 1934. The controls were kept clean weeded, the weeds being left on the surface. Plot 2 was weeded when weeds reached flowering stage. The plots having contour hedges (2 and 4) had three hedges of *Crotalaria* species in each case; the hedges were on bunds 32 feet apart, the lowest being 2 feet above the concrete tank. The procumbent cover crop used was *Dolichos hosei*; the mixed cover crop consisted of *Crotalaria* species and *Canavalia ensiformis*, and was cut back twice during the period, the loppings being left on the surface.

The treatments received during the period February, 1934, to 30th May, 1935, were as follows:—

April, 1934.

19th:

(*a*) Each plot holed and dug over prior to planting.

21st:

(*b*) Hedges and cover crops planted.

30th:

(*c*) Coffee planted.

March, 1935.

3rd:

(*d*) Each tree in each plot was envelope forked to a radius of 2 feet.

3rd:

(*e*) Control plots (1, 3, 5, 8) were *jembe* forked (from top to bottom once; similarly with the contour hedge plot, 2).

3rd:

(*f*) Contour hedge and procumbent cover crop (4) and procumbent cover crop (6) and mixed cover crop (7) plots were envelope forked over the whole of their area.

(*g*) The contour hedge plot (2) was weeded three times during the period 1-2-35 to 30-5-35.

The amount of soil in each tank prior to 1st February, 1935, was negligible. The figures obtained can therefore be considered to represent the degrees of erosion which have occurred during the period 1st February, 1935, to 30th May, 1935.

The results obtained are given in Table I. Those for run-off represent

actual run-off, the volumes of water due to rainfall have been deducted.

The loss of soil per acre from the controls varies from 8.3 tons to 18.5 tons. It is possible that variation in soil conditions may be responsible for a portion of this difference, but from an examination of the individual plots it appears that the merging of individual furrows appears to have occurred more on Plots 8 and 5 than on the other two; this would appear to be mainly responsible for the differences.

Plot 2, Crotalaria hedge, has a high figure compared with those of the other anti-erosion treatments. It is partially explained by two breaks through, due to gaps in the hedge, and also by the fact that the hedges became silted up to the extent of 2-3 inches and then an overflow occurred.

TABLE I

EROSION DEMONSTRATION

CORRESPONDS TO LONG RAIN PERIOD, FEBRUARY TO MAY, 1935

SLOPE 1:6

		I	II	III	IV	V	VI	VII	VIII
Plot No.	PLOT Each 1/30 acre	Actual weight dry soil eroded during period 1-2-35 to 30-5-35	Loss per acre	Percentage by weight of top foot of soil	Expressed as inches of soil	Weight of soil eroded during period 9 a.m., 7-5-35 to 9 a.m. 8-5-35—Rainfall 56 mm.	Run-off during corresponding period	Run-off per acre: 9 a.m. 12-4-35 to 9 a.m. 13-4-35—Rainfall 104 mm.	During period 9 a.m., 3-5-35 to 9 a.m., 7-5-35—Rainfall 142·6 mm.
		Tons	*Tons*	*Per cent*	*Inches*		*Gallons*	*Gallons*	*Gallons*
1	Control ..	·415	10·902	0·75	0·09	—	—	1,560	6,420 correspond to 6·9% of rainfall per period
2	Crotalaria hedge (32 feet apart)	·028	0·856	0·059	0·007	—	—	1,560	3,420 (4% rainfall per period)
3	Control ..	·330	8·339	0·57	0·07	—	—	2,460	5,520
4	Crotalaria hedge and cover crop—Dolichos hosei ..	·003	0·08	0·0055	0·0007	—	—	1,440	—
5	Control ..	·574	14·103	0·967	0·12	476 lb., i.e. 6·3 tons per acre	183 gals. = 5,490 gals. per acre	2,610	4,560
6	Cover crop procumbent—Dolichos hosei	·006	0·174	0·0114	0·001	1 lb., i.e. 30 lb. per acre	158 gals. = 4,770 gals. per acre	1,740	1,320 (1·4% of rainfall)
7	Cover crop erect (Crotalaria and Cannavallia)	·006	0·174	0·0114	0·001	—	—	2,040	2,520
8	Control ..	·735	18·557	1·27	0·15	—	—	2,940	4,620

The quantities of eroded soil and run-off water on Plots 5 (control) and 6 (cover crop) for the twenty-four hours commencing 9 a.m. of 7-5-35, during which time there was a precipitation of 56 mm., are of interest (Columns V and VI of Table I). The rainfall up to that time had been 1,013.8 mm., and from 1st to 6th May 288.5 mm. had fallen; the quantities are not due therefore to a sudden downpour of 56 mm. on a dry, powdery soil. The quantity of run-off water in the case of Plot 5 is 183 gallons, and in that of Plot 6, 158 gallons, a ratio of 1.16 to 1; but the loss of soil in the respective instances is 476 lb. and 1 lb., in itself demonstration of the necessity of curtailing the speed and accumulation of water if erosion is to be prevented, and also of the effectiveness of a ground cover in preventing the accumulation of water.

The average run-off for the control plots for the period 3-5-35 to 7-5-35 was equivalent to 5,280 gallons per acre, the average of the Plots 2, 6 and 7 was equivalent to 2,630 gallons per acre; i.e. half that of the controls. It remains to be proved whether any advantage as regards soil moisture has been accrued by the apparent increased absorption of water by the Plots 2, 6 and 7, and, should there be any such advantage over a long period, if it counterbalances any loss of moisture which may occur as a result of transpiration by the cover crop in Plots 2, 6 and 7.

It should be noted that the demonstration has been laid out on an actual slope of 1:6, and the accumulation of water on the slope above it is prevented from flowing over the demonstration. If the demonstration were to be extended to include this area, the rate of erosion per unit area will increase, due to increased accumulation and speed of water, with its consequent eroding power.

TABLE II

RAINFALL—1ST FEBRUARY TO 31ST MAY, 1935

Date	February	March	April	May
	mm.	*mm.*	*mm.*	*mm.*
1	—	4·7	—	30·0
2	—	—	30·4	69·7
3	—	8·9	20·4	39·4
4	0·1	7·6	0·25	7·8
5	17·2	—	0·3	21·6
6	1·2	0·5	13·6	120·0
7	0·5	—	0·5	33·7
8	3·4	21·7	2·3	74·0
9	—	4·5	9·3	21·5
10	3·25	6·6	0·6	53·0
11	—	6·8	—	35·7
12	0·75	5·5	5·5	9·0
13	2·8	12·9	*104·0	2·6
14	—	—	10·8	—
15	—	2·4	3·7	—
16	—	—	—	0·8
17	—	—	1·0	1·1
18	—	0·5	0·6	1·4
19	—	—	16·3	25·5
20	45·75	18·1	1·25	25·7
21	†87·0	3·6	—	2·0
22	1·5	—	—	24·1
23	—	—	—	18·3
24	31·0	0·5	1·5	22·8
25	32·0	2·2	0·3	7·8
26	0·5	5·5	16·2	70·8
27	6·9	—	47·3	10·0
28	—	—	34·5	0·4
29	—	—	2·8	—
30	—	0·5	29·0	1·6
31	—	—	—	0·5

*76 mm. within one hour.
†42 mm. in one hour.

APPENDIX I (TABLE III).

General Description of Soil.—The soil is classified as a tropical red earth, partially laterized; the molecular ratios SiO_2/Al_2O_3 and SiO_2/R_2O_3 are 1.7 and 1.4 respectively. The field texture is that of a clay loam with a fairly high moisture-retaining capacity (66 per cent). The subsoil is a deep freely drained chocolate-red clay, friable throughout the profile. The topsoil, 0-6 inches, contains 4 to 5 per cent organic carbon, and the immediate subsoil, 6-12 inches, 1.5 to 2.5 per cent. The exchangeable base content averages 30 milligram equiva-

lents per cent. Typical analytical data are tabulated below:—

	0–6 inches	6–12 inches
pH	7·2	7·0
Total exchangeable bases	30·0	28·0
Clay content	60·4	68·3
Molecular ratios—		
SiO_2/Al_2O_3	1·66	1·70
SiO_2/R_2O_3	1·42	1·45
*Index of texture	47	44
Inorganic loss on ignition	9·7	9·8
†Moisture equivalent (Bouyoucos)	51	45
Maximum water retaining capacity	66	60
Air dry moisture	11·5	11·5

*F. Hardy (J. Agric. Sci., 1928, *18*, 252).
†G. Bonyoucos (Soil Science 1929, *27*, pp. 233–240).

Uniformity of Texture.—In a demonstration of this kind it is necessary to note any variability in texture. Each plot was sampled at the top of the slope, in the middle, and at the bottom. As there was, however, no difference between the texture of these three subdivisions of each plot, as judged by the index of texture, subsequent analytical data were made on composite samples of each plot.

There does not appear to be any appreciable difference in texture between the plots; the only factor affecting erosion which varies is that of organic matter content.

Eroded Material. — Mechanical analysis of the eroded material from each plot indicated that the soil had been eroded *in toto*; i.e., erosion did not involve the removal of clay, silt or sand individually.

Effect on Soil Moisture.—In view of the variation in run-off from the different plots, it was thought that differences in soil moisture content might be evident five or six weeks after the cessation of the long rains. On 18th July each plot was sampled at depths of 0-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches. The results show no definite indication of moisture conservation under any of the treatments, in spite of the moister feel and look of the soil under procumbent cover crop.

TABLE III

MECHANICAL ANALYSES

A. Plots—Top Soils, 0–6 Inches

	Plot No.							
	1	2	3	4	5	6	7	8
Stones and gravel	1·1	1·5	1·4	1·1	1·6	0·8	1·0	0·4
Coarse sand	5·1	5·0	6·2	5·2	5·7	6·5	5·3	5·0
Fine sand	7·5	6·9	7·2	7·0	6·9	7·1	7·6	7·5
Silt	9·6	10·6	10·0	10·8	10·5	11·4	12·1	10·9
Clay	60·7	59·3	61·5	59·4	61·1	60·4	60·3	59·9
Air dry moisture	11·7	12·2	11·5	11·5	11·1	11·5	11·0	12·2
Total loss on ignition	16·5	17·2	18·0	17·6	18·2	17·5	17·0	17·0
Organic carbon	3·8	4·5	5·1	4·7	4·6	4·6	4·4	4·2
Inorganic loss on ignition	10·0	9·5	9·2	9·5	10·3	9·6	9·4	9·8
Index of texture	46·0	47·5	49·0	47·5	47·5	46·5	46·5	46·0

(*Table continued next page*)

A. Plots—Sub-soils, 6–12 Inches

	Plot No.							
	1	2	3	4	5	6	7	8
Stones and gravel	1·0	1·4	1·7	2·3	1·6	1·0	0·9	0·6
Coarse sand	4·9	5·0	4·8	4·7	5·3	5·9	5·2	4·7
Fine sand	6·8	6·2	6·9	6·1	6·5	5·8	6·2	6·5
Silt	7·8	8·0	7·6	8·7	9·5	9·0	9·2	9·8
Clay	68·6	67·9	68·8	69·0	67·3	68·2	68·0	68·4
Air dry moisture	11·0	11·5	11·4	11·7	11·3	11·2	10·9	11·7
Total loss on ignition	13·0	13·6	14·2	13·3	13·9	13·7	13·5	13·7
Organic carbon	1·9	2·2	2·5	2·2	2·4	2·3	2·2	2·1
Inorganic loss on iginition	9·7	9·8	9·9	9·5	9·8	9·7	9·7	10·1
Index of texture	44·0	44·0	44·5	44·0	44·5	44·5	44·0	44·0

B. Eroded Material

	Plot No.							
	1	2	3	4	5	6	7	8
Stones and gravel	0·8	1·0	0·9	Amount negligible	1·1	0·8	1·1	0·8
Coarse sand	4·0	6·0	5·5		5·5	6·2	7·5	6·5
Fine sand	7·0	8·1	7·3		6·3	7·5	7·5	5·0
Silt	10·6	13·1	10·2		11·5	11·2	12·8	14·1
Clay	57·3	56·6	60·5		58·1	61·2	59·4	59·4
Air dry moisture	17·9	13·3	12·7		16·9	11·4	11·9	13·6
Total loss on iginition	14·2	17·3	16·2		15·0	16·7	16·4	14·6

Moisture Contents of Plots, 18–7–35

	Plot No.							
	1	2	3	4	5	6	7	8
0–6″	38	39	37	43	40	42	41	40
6–12″	41	41	44	44	43	41	44	42
12–18″	44	45	45	44	43	43	42	41
18–24″	41	46	47	44	45	44	47	45

Per cent on dry soil, i.e. 100 grs. of dry soil contained x grs. of moisture.

The Place of Silage in the Dietary of Live Stock

By M. H. FRENCH, *M.A., Dip. Agric. (Cantab.), Department of Veterinary Science and Animal Husbandry, Tanganyika Territory.*

The feeding value of silage is naturally dependent upon the crop from which it has been produced. As almost any green succulent vegetation can be converted into silage, it is obvious that no average value can be taken as representative of all the types of silage produced. In East Africa, the silage most frequently encountered is either made from maize or from grasses.

The grasses which are most suitable for ensilage are, firstly, elephant grass (*Pennisetum purpureum*), and then others such as Guinea grass (*Panicum maximum*), and Rhodes grass (*Chloris gayana*). In addition, silage can also be made from ordinary pasturage that has been cut for hay but which cannot be dried properly because of stormy weather. I have shown that the feeding value of silage made from local grasses is, weight for weight of dry matter, equal to that of the hay which could be made from the grass.

Maize has proved itself all over the world as the crop most suitable for silage production. It is not difficult to grow in warm countries, produces good yields of green forage, and is easily converted into good silage. It enjoys such popularity that most farmers in sub-tropical regions think of "silage" as synonymous with "maize silage". East Africa is no exception to this, and most of the settlers who make silage grow maize for this purpose. In the following notes therefore maize silage will be dealt with, though the same remarks will of course apply to other types of silage when allowance is made for differences in composition and digestibility.

Maize silage may be of five types, as differentiated by Woodman into: —

(*a*) *Sweet dark brown silage,* produced when dry crops are ensiled and insufficiently consolidated. This silage has a pleasant smell and is readily eaten by most classes of stock. Owing to the excessive fermentation during its production it has lost much of its feeding value.

(*b*) *Acid light brown silage* is the form most often produced, and requires no special precautions in its preparation. This type has a good feeding value, and is much relished by cattle, sheep and goats.

(*c*) *Sour silage* is the variety produced when very wet or succulent immature fodders are ensiled. It has an unpleasant smell, is generally unappetizing to stock, and is often refused by most classes of animals.

(*d*) *Musty silage* results when moist fodders are insufficiently packed. It is usually left by all classes of stock.

(*e*) *Green fruity silage* is a most attractive looking foodstuff. The original colour of the crop is little changed and the silage is greedily devoured by all classes of stock. Its preparation depends on the ensilage of immature crops, and adequate but not excessive packing in the silo. It needs more care in its preparation than does acid light brown silage, and consequently is less frequently encountered.

The feeding value of silage differs from that of the green crop from which it was prepared owing to unavoidable

losses in the silo. These losses are chiefly due to the respiration of the plant tissues and to bacterial, fungal and enzymatic activities. There is a loss of carbohydrates owing to these processes, some cellulose is broken down, and the hydrolysis of some protein material results. There is always a certain amount of drainage of plant juices and water from a silo, and this liquid carries away with it certain soluble salts and some of the protein breakdown products. This list of losses sounds formidable, yet the losses during ensilage need not be greater than during haymaking.

Green fruity silage is more palatable and possesses a higher feeding value than any other type. Acid light brown silage is the next best, whilst the sweet dark brown silage varies in feeding value according to the extent of the fermentative losses during its preparation. Sour silage usually has a good feeding value if the stock will eat it.

Silage is a succulent food, and most farmers want to know what foodstuffs it will replace. When compared with roots, we find that silage possesses much more fibre and less of the soluble carbohydrate than roots. The ether extract forms a larger proportion of the total dry matter in silage than in roots owing to the presence of a number of organic acids produced during incomplete cell respiration and by the agency of micro-organisms. Roots are fed with roughages to increase the rate of passage through the alimentary tract. Silage also has this effect, but owing to its high fibre content its action is very much less than that of roots. Silage and roots cannot be closely compared therefore, and we usually find in nutritional literature that about 6 lb. of silage can replace 10 lb. of roots, plus a small amount of roughage.

Analyses show that silage compares most closely with the green crop from which it is prepared, and on a dry matter basis it also compares closely with hay made from the same green crop. It is thus more reasonable to expect silage to replace green pasturage in the winter or drought periods than to regard it as a substitute for roots. Work at Mpwapwa has proved that in East Africa, as in other parts of the world, equal weights of dry matter in the form of silage or hay have the same feeding value.

In Tanganyika the average water content of silage is between 75 and 80 per cent of the total weight. Hay on the other hand contains approximately 90 per cent of dry matter. Therefore 100 lb. of silage will be equivalent to about 25 lb. of hay. Even this equivalence is not really just, because hay, with an *ad lib.* amount of water, can never equal the green crop, and so will never be strictly comparable with silage.

Compared with its green crop, silage is able to replace it almost weight for weight. Silage can be fed to almost any class of stock, but the following qualifications are perhaps worth noting:—

Silage for Calves.—Calves will usually begin to eat chaffed silage when three months old. They will consume about 2 lb. daily at this age, and the amount will increase steadily to about 10 lb. when six months old. As with all classes of stock, calves should never be given more silage than they will eat up quickly. Further, the feeding of too much silage at the expense of the concentrates part of the ration may reduce the rate of growth of all young stock, and should be avoided at all costs.

Silage for Steers.—Yearlings will eat about 15 lb. daily and two-year-old cattle will take up to 20 lb. daily. During the fattening of steers the amount should never exceed 20 lb. per day, otherwise the rates of gain may be reduced.

Silage for Dairy Cows.—Dairy cows

will eat daily up to 50 lb. for a European breed and about 25 lb. for a zebu. A normal daily ration is about 20 lb. per head in the dry season.

Silage for Horses.—Brood mares and idle horses will eat about 12 lb. of silage daily, if chaffed. Working horses should not get silage.

Silage for Donkeys.—Resting or breeding donkeys may get up to 8 lb. of silage daily, but working donkeys should not get it.

Silage for Sheep.—Breeding ewes may be given up to 2 lb. of silage daily, though 1 lb. would be normal. Young sheep may also be given up to 1 lb. daily.

Silage for Pigs.—Breeding sows and boars may be allowed silage, if chaffed, but as a normal farm practice it is not to be recommended, owing to the waste involved.

As Oldershaw has pointed out, certain animals dislike silage and will never eat it. If it is attempted to force such individuals to eat the silage, their production (either as milk, live-weight gain, or work) will suffer.

Feeding values are usually measured in terms of digestible protein and energy equivalents. The feeding value of silage cannot be expressed adequately by such terms. Silage is produced so that a succulent feed may be available during periods of drought. At such seasons the value of succulence cannot be assessed in terms of feeding units, and a succulent food possesses may other attributes. The succulence increases the rate of passage of other dry fibrous foods through the alimentary tract. By this means, more food can be dealt with by the same animal. The succulent food also stimulates the appetite and the production of enzymes in the stomachs.

Silage possesses a considerable vitamin content, all the vitamins being present. Dried-up herbage contains very few vitamins, and so silage has a very beneficial effect, not only on the health of the animal, but also on the nutritive quality of such animal products as meat and milk.

In East Africa the greatest use of silage is made by dairy farmers. The markedly beneficial effects of silage on the milk yield during the dry season is obvious to all who have tested it. Not only is the milk yield increased, but the health and appearance of the animals are improved considerably.

Advantages of Silage.—Some crops, such as grain, need to be kept for some time before they are fit for general stock feeding, whilst other crops, such as roots, can be kept only for a limited period. Well-made silage, on the other hand, is fit for consumption by all classes of stock a fortnight after ensiling. It can also be kept for long periods (up to five years) without suffering any loss of palatability or feeding value.

Silage-fed animals in the dry season carry much more bloom than similarly well-fed animals receiving dry fodders only. The general health and appearance of stock is much improved by feeding silage. Silage-fed animals do better and go ahead quicker when turned out to graze at the beginning of the rains than do animals fed only on dry roughages.

Summary.—Silage is thus a palatable form of green food, capable of maintaining a healthy digestion of other dry foods and aiding their passage through the bowels. If well made, it can be fed without risk to all classes of stock.

It produces a marked improvement in health and general appearance, whilst at the same time it increases the productive power of the animal. Its high vitamin content enables the animal products to contain their normal high content of vitamins, even at the end of a long drought period.

Raising and Planting Cinchona

By F. M. ROGERS, *Superintendent of Plantations, Amani Research Station.*

Raising from Seed.—The soil should consist of equal parts of loam, leaf soil, and sand. The seed pans or boxes should be clean, drained with a small quantity of broken crocks or shells, covered with a good sprinkling of well-decayed leaves. They should be filled with the prepared soil to within half an inch of the top, pressed firmly, but not too hard, and then given a thorough soaking in a bath, tub, or other receptacle. They should be allowed to drain for a few minutes before sowing the seed.

The seed, which is extremely light, should be sown evenly all over the pan or box, and covered lightly with fine soil. *No water* should be applied after sowing, the previous soaking of the pans or boxes being quite sufficient. These should then be placed in a trench, which is made moist by watering previous to placing the seed pans inside; at Amani we have a bed dug out some two feet deep, with a concrete wall built round. The trench is then covered with corrugated iron sheets or grass roofing, to keep out the rain (the latter being preferable unless grass is placed on top of the corrugated iron) until after germination. This takes place in about 15 to 20 days. The covered trench not only keeps the seeds at an even temperature, but ensures that no watering is needed until after germination. Should the trench show signs of becoming dry, the sides should be syringed or watered, also the spaces between the seed pans. No water should be given direct until after germination unless absolutely necessary, and then the pans should be resoaked and not watered on top. At the same time, great care should be taken that the seed pans never become dry, as once the seed pan is dried out after germination has commenced, all are lost. This method has been carried out at Amani with complete success, resulting in nearly 100 per cent germination.

The seedlings are pricked out into boxes as soon as they are large enough to handle, and afterwards transplanted to prepared beds. There they remain until they are 8 to 12 inches in height, when they are transplanted to their permanent quarters, that is if the season is suitable for such work. At no time during the seedling stage of Cinchona-growing should watering be done without the greatest care, and only when definitely needed. Damping off in the seedling stage through careless watering is the chief cause of failure.

Planting.—The transfer of the young plants to their permanent quarters is not difficult. Holes should be prepared, 1½ metres apart, the plants lifted from the seedling beds with a ball of soil, and planted firmly. This work should always be carried out in the rainy season. Planting out at 1½ metres apart allows of alternate trees being cut at five years, and the remainder, which give the main crop, at eight years; one shoot or sucker being allowed to grow from the base of the trees cut at five years, so that when the main cutting is done at eight years these trees will have secondary growth three years of age, and so on.

The following points may be noted: The percentage of alkaloid in the bark does not increase after the eighth year (which determines the harvesting period), so that the first crop cut at five years is not fully developed. Nevertheless, trees

planted at this distance apart must necessarily be thinned out, or they would become too close and make spindly growth. Close planting is an advantage in the early stages, as it helps the trees to grow straight. The young suckers after each cutting also grow straight in order to get up to the light.

As to the altitude for growing Cinchona, 3,000 ft. upwards is suitable. Cinchona thrives at Amani at 2,500 ft., but the climate is exceptionally cold for the altitude; 3,000 ft. to 5,000 ft. should be ideal.

Freshly cleared forest land is much the best for opening up Cinchona plantations, but it is not essential if the soil is fairly rich in organic matter.

For the harvesting of the bark, ordinary plantation tools only are required, with blunt pointed knives, shaped like a paper-knife, and made preferably of bamboo or buffalo-horn, for peeling iron knives are apt to discolour the bark. The primary incisions are, of course, made with a sharp-pointed steel knife.

Comparison of Types of Native Cows at African Training Centres, Kenya

There are now established in the Colony, under the control of the Animal Industry Division, Department of Agriculture, Kenya, five centres at which work is being carried out with a view to developing the potential resources of the indigenous cows of the various pastoral tribes for the purpose of milk production.

It is anticipated that, under conditions of more skilful management and selective breeding, the types at each centre will improve in conformation, and that the physical characteristics associated with milk production will be emphasized in succeeding generations; hence it was decided to undertake a brief survey of the herds at each centre. The data recorded may be of value for purposes of comparison in the future. The cows at these centres were not specially selected, but are typical of the animals owned by natives in the respective districts.

The herds at each station were examined for uniformity of type and indications of milk-producing capacity. Measurements of 25 cows of each type, including height at point of shoulder, length of body from shoulder to seat of tail, girth behind the shoulder, and distance between hook bones, were carried out for purposes of comparison. The average of these measurements for each type is recorded below.

Machakos.—The Akamba cows at this centre are spare of build, narrow of body and leggy, with small udder development, active in their movements, as though adapted to travelling long distances in quest of food. Twenty per cent of the milking herd showed milk veins, but in some cases a low yield resulted from the presence of small and too closely placed teats. The highest daily yield being recorded was 12 lb. Black, white, and brown were the dominant colours, the majority of the cows showing more than one colour coat.

Maseno.—The Central Kavirondo cattle at this centre are comparable in size and build with the Akamba cattle, showing a similar diversity of colour. About forty per cent of the number examined showed milk veins coming well forward, and these had recorded the highest yields. An average daily yield of 5 lb. was recorded, while the best individual yield was 13 lb. The calves from the herd, weighed at birth, averaged 32 lb.

Sangalo.—The North Kavirondo cattle at this station are comparable in size and general conformation with the Akamba and Central Kavirondo types. They do not suggest a tendency to milk production, their milk veins and udders being rather undeveloped, and in this respect they appear inferior to the two types discussed above. There is a diversity of colouring—blacks, browns, black and white, roan and white, brown and white, being represented in the herd. The highest yield was 10 lb. per day, the average being 4½ lb. At birth, the calves to date averaged 33.5 lb.

Baraton.—When the herd of Nandi cows at this centre was assembled there was no hesitation in placing them an easy first among the types of native cows which had been examined. They are larger of body, relatively shorter in leg, with a conformation definitely suggestive of milk production. At least eighty per cent showed prominent milk veins, while the hindquarters gave ample room for udder development, and the teats were relatively large and well spaced. Their

MEASUREMENTS OF NATIVE COWS AT AFRICAN TRAINING CENTRES

	Height at shoulder	Length of back to seat of tail	Girth	Breadth at hips
	Inches	*Inches*	*Inches*	*Inches*
MACHAKOS—Akamba Cows—				
Average figures for 25	44	35	54	13·3
Lowest	40	31	49	12
Highest	48	38	58	15
Number of cows below average	11	9	10	15
Number of cows above average	8	12	12	10
MASENO—Central Kavirondo Cows—				
Average figures for 25	44	34·5	54	13·7
Lowest	37	31	51	12
Highest	47	37	58	16
Number of cows below average	14	12	12	8
Number of cows above average	8	13	9	17
SANGALO—North Kavirondo Cows—				
Average figures for 25	45	35·5	55	13·7
Lowest	41	32	51	12
Highest	48	39	60	16
Number of cows below average	9	17	16	17
Number of cows above average	10	8	7	8
BARATON—Nandi Cows—				
Average figures for 25	45·5	36·5	57·7	15·3
Lowest	41	34	52	13
Highest	48	41	62	17
Number of cows below average	14	13	8	13
Number of cows above average	11	12	17	12
NGONG—Boran Cows—				
Average figures for 25	50	42·9	63	18·4
Lowest	49	39	60	18
Highest	51	49	69	20
Number of cows below average	2	6	6	8
Number of cows above average	6	10	10	4
NGONG—Machakos Cows—				
Average figures for 25	45	38	58	16
Lowest	44	35	56	16
Highest	48	40	59	17
Number of cows below average	6	7	6	Nil
Number of cows above average	12	10	14	Nil

milk records supported the impression created by their general appearance; a high percentage have yielded over 200 gallons in their first lactation period. The herd may be divided according to colour, blacks and reddish-brown being dominant. There is little to choose between the yields of the blacks and the browns, and it is possible to breed two herds on a colour basis at this centre. The calves at birth averaged 41.5 lb.

Ngong: Type 1 (*Machakos*).—These cows are spare of build, narrow of body, and leggy, but on the whole are bigger in conformation than the heifers at Machakos Veterinary Centre. They show well-developed milk veins and udders. This is due to the fact that these heifers were selected from a miscellaneous lot brought to this station. An average daily yield of 8 lb. was being recorded, while the highest individual yield was 16¾ lb. The calves from the herd, weighed at birth, averaged 35 lb. The dominant colours are brown, black, and white. (*Continued on page* 250)

The Climate and Weather of East Africa—III

By W. A. GRINSTED, *Acting Director, B.E.A. Meteorological Service.*

The most important climatic factor in East Africa is rainfall, and the mechanism of its production is worthy of note. Speaking generally, there are three "types" of rain: frontal, orographic, and convection. When two masses of air of different temperature and humidity come into contact, the less dense air will be the warmer air which will probably have a large moisture content. As this air rises it expands and cools until part of the moisture condenses, forms clouds, and falls as rain. This rain will fall in the neighbourhood and along the line of the meeting of the two air masses, and is called "frontal" rain. This type of rain is that most frequently encountered in temperate regions and where the movements of differing masses of air may be traced.

Orographic rain, as the name implies, is associated with topographical features of the land. If air is blowing steadily in a certain direction across the sea it will absorb moisture. When this air comes up against rising ground or hills it will be forced up, and through rising cool down. If it is cooled sufficiently, clouds, mist or rain will result, and that is why more rain is received at higher altitudes, other things being equal.

The third type, convection rain, is that most generally met with in East Africa; it is essentially of the showery type, and varies from the light shower to the heavy thunderstorm. In this type of rain no large horizontal movement of air is required, and in fact calm or light variable winds are favourable circumstances. Further, it will be preceded by fine warm weather in which the ground gets very warm. The surface layer of the air is heated by the ground, is made less dense, and so should rise to higher levels. Actually, however, this heated layer persists next to the ground until some small disturbance starts. The heated air then breaks through in a comparatively small area, and is forced up through this "funnel" to heights varying from two to thirty thousand feet. If the air rises high enough to be cooled below its dew point moisture will condense and cloud will form. This condensation in itself requires heat (the latent heat of evaporation), and so the air is cooled still further, and the air rises until it finds itself at a height where it has the same temperature as its surroundings. The resultant condensation and the large vertical currents involved sometimes result in extremely heavy thunderstorms, accompanied by heavy rain and hail.

The thunderstorm is the result of these violent vertical currents, in that rain falling from the cloud is caught in the current, the drops break up and are carried up into the top of the cloud again. In breaking up into smaller drops the rain becomes positively charged, while the surrounding air acquires a negative charge. In the heavier storms the drops are cooled below the freezing point on their upward excursions, and only partially melt when falling. As the process is repeated several times before the drops finally fall to the ground, the hail is made up of a series of layers, and if a hailstone is cut in half it will be seen to have somewhat the appearance of an onion.

It may be remarked that the mere existence of vertical currents in the air will not necessarily result in rain or even in clouds. The amount of moisture in the air must be sufficient.

Examples of weather conditions resulting in the different types of rain will be given, but it is first desirable to explain the drawing of a synoptic chart. A synoptic weather chart shows the weather conditions at a stated time over a certain area, and for this purpose observations are taken over the required area at a certain time (in Africa, usually 6 a.m. G.M.T.), and telegraphed to a central office. In the office at Nairobi observations are received by telegraph from 11 stations in Uganda, 9 in Kenya, 10 in Tanganyika, and from Zanzibar. By wireless, messages are received from Egypt and the Sudan, Northern and Southern Rhodesia, Madagascar, Portuguese East Africa, and West Africa. The messages include information as to past and present weather, cloud, wind, visibility, temperature, pressure, humidity, rainfall, and, in the case of certain stations, the direction and velocity of the winds at various levels above the station. The messages are decoded and the instrumental readings reduced to a common or standard level. The standard level used by the B.E.A. Meteorological Service and by the Meteorological Service of Southern Rhodesia for inland stations is 1,200 dynamic metres, or 4,022 feet. In reducing to this level, an allowance for a fall of temperature of 3° F. for each rise of 1,000 feet is made, while the formula for pressure takes into account the decreasing density of the air with increasing altitude. Coastal observations are reduced to mean sea level and to the standard level, but less reliance is placed on the latter values because, not knowing the actual temperature of the whole of the air column above the station certain assumptions have to be made which may affect the readings considerably.

Having obtained and reduced the readings from the various stations the information is plotted on the chart. This is a blank chart of the area under consideration, and the data is placed over each station by means of various code figures and symbols, so that the meteorologist may tell at a glance the state of the weather over a large area. Isobars are then drawn, both at sea level and at the standard level, and general air movements noted, together with the amount of moisture in the air over various regions.

Air flows from regions of high pressure to regions of low pressure, and, due to the effect of the rotation of the earth, appears to flow round an area of low pressure in a clockwise direction in the southern hemisphere and anti-clockwise round an area of high pressure. In the case of large pressure regions or belts a wind, instead of blowing, say, from south to north, will be deflected into a south-east wind. This effect becomes less as one approaches the equator, and reverses in the northern hemisphere, so that the south-east wind would become southerly on the equator and south-west further north.

When the sun is to the north, that is to say, from April to September, there is, as mentioned in the first article, a general south-easterly wind blowing, and influences on the weather of East Africa are mainly to be found to the south-east. If, on examining the weather map, pressure is seen to be high over Madagascar, one may assume that the south-easterly current will blow strongly and steadily along the coast. This air current will be well charged with moisture, owing to its long passage over the sea, and when it reaches the coast and on rising ground it will form cloud and rain. This rain will tend to fall whenever rising ground is encountered, and will be found all along the "edge" of the Kenya Highlands and round into the Northern Frontier District.

Generally speaking, regions of high or low pressure (anticyclones or depressions) may be seen to move up from South Africa, and so a certain amount of warning is given.

When pressure is low over Madagascar or the Mozambique Channel, the south-easterly current is deflected, weather clears over the coast and highlands, and little general air movement is noted. Under these conditions convection rains develop, and the districts in which they are likely to appear are partially indicated by the humidity of the air. An additional aid to forecasting thunderstorms is great variation of direction with height of the upper winds, this information being obtained by means of small balloons.

It will be seen that the weather during this mid-year period is controlled by the travelling pressure systems south of latitude 15° S. superimposed on the general circulation which results in the south-east trade winds. An examination of the mean values of pressure for this period shows that pressure increases southwards from the equator, but it is the variations from this average condition which produce the weather.

During the other half of the year pressure is, generally speaking, higher to the north, and the main influences on our weather must be sought there. Unfortunately the information received from the north is mainly confined to the Nile Valley, and the details of the influence of the pressure systems are not yet understood. It has been observed, however, that during this period of northern winter there is an incursion into Kenya of comparatively cold and dry air which produces clear fine weather. This is most pronounced during January, and it is found that during the temporary withdrawal or retreat of this cold air convection showers form over the Highlands and Lake Area. It is interesting to note that during the other half of the year, the southern winter, an incursion of cold air is associated with active trade winds, and results in rain and mist on the coast and on the hills.

Note.

The heading of the diagram in No. II of this series was inadvertently omitted. It should read as follows: "Diurnal and Annual Variation of Meteorological Elements at Zanzibar (.....), Tabora (———), and Kampala (. — . — . —)."

Comparison of Types of Native Cows etc.

(*Continued from page* 247)

Ngong: Type 2 (*Boran*).—These cows are deep of body, short of leg, with wide hindquarters, providing ample udder space. They show well-developed milk veins and udders, also on the average their teats are larger than in other breeds. It will be noticed, from perusal of the following tables of measurement, that the Boran cows in this station are considerably larger than the corresponding type at Isiolo Station. This is due to the fact that the Boran cattle at this station were selected from a herd bred for beef. The average daily milk yield recorded was 9 lb., while the maximum yield was 24 lb. The calves from the herd, weighed at birth, averaged 40 lb. There is a diversity of colouring—brown, white, and roan and white being represented in the herd.

Improvement of Native Cattle by Selective Breeding and Herd Management

Records of Improved Production of Milk by the Use of Natural Grazing only: Experiments Carried out at the Native Training Centre, Ngong.

By John Anderson, *Instructor in Stock, Animal Industry Division, Department of Agriculture, Kenya.*

Indigenous breeds of cattle in tropical and sub-tropical countries are capable of vast improvement in production. A great deal of evidence exists in support of this. For example, the Madras Agricultural Department began in 1918 to build up a pure herd of "Ongole" cattle, starting with 48 cows, and the following improvement in milk yield has resulted:—

	Yield			Days dry
	Average daily	Total	Best individual	
	Lb.	*Lb.*	*Lb.*	
Foundation stock ..	9·8	2,674	14·1	177
Resulting stock (with over two lactations) ..	11·5	3,526	25·6	147

Confirmatory figures are available from Ferozepore, another dairy farm in India:—

Year	Average per cow in milk	Average per whole herd
	Lb.	*Lb.*
1914 ..	11·6	5·9
1919 ..	14·7	11·3
1926 ..	18·0	12·5

In view of the valuable results likely to accrue, a policy of improving native stock by selective breeding and herd improvement was formulated in Kenya Colony in 1928. Work was begun in that year and is now conducted at five stations in the Colony, namely, Ngong, Machakos, Baraton, Sangalo, and Maseno.

The preliminary data here recorded were obtained at the Ngong Station, and they give clear indication of the valuable potentialities inherent in native stock. The experiments are still in progress, and it must be understood that no final conclusions can be reached for some time to come. Nevertheless, the preliminary figures are considered of sufficient interest and importance to warrant publication, especially as no similar production data exist to serve as a guide to farmers in Kenya as to what performance may be expected from native stock kept under improved conditions of management.

The Ngong Station is situated in Masai territory at the foot of the Ngong Hills, 6,400 feet above sea level, and some fourteen miles from Nairobi. The climate is temperate, and the average rainfall about 30 inches per annum.

Animals and Methods of Husbandry.—Two types of cattle are employed, namely, Boran and Masai. The Boran native type were obtained from a European farmer under whose care a certain amount of selection had taken place. The Masai type were selected at random, and were typical examples of the unthrifty cattle that exist under hardship conditions in the native reserve. It is reckoned that none of the animals of either type was under five years of age at the date

they were chosen to form the foundation stock.

The feed of the herd consists solely of the natural pasture available at the Ngong Station. No concentrates are allowed, but the animals have access to a natural salt lick. An analysis of two samples of the pasture, carried out at the Rowett Research Institute, gave the following figures: —

SAMPLE I.
TAKEN AFTER A LONG PERIOD OF DRY WEATHER.

Dry matter	100
Nitrogen	0.990
Acid soluble ash	3.098
Lime (CaO)	0.672
Soda (Na_2O)	0.177
Potash (K_2O)	0.658
Phosphate (P_2O_5)	0.332
Chlorine (Cl)	0.208

SAMPLE II.
TAKEN TWO WEEKS AFTER THE BEGINNING OF RAINS.

Dry matter	100
Nitrogen	1.425
Acid soluble ash	3.733
Lime (CaO)	0.620
Soda (Na_2O)	0.020
Potash (K_2O)	0.972
Phosphate (P_2O_5)	0.435
Chlorine (Cl)	0.283

At first the animals were mated to bulls of their respective breeds, with unknown records, while later a bull bred on the station from a recorded dam was used. During the three months prior to calving, cows and heifers are tied up twice a week in the stalls and handled, in order to accustom them to hand milking. Immediately after birth, the calves are removed from their mothers, and are not allowed to be reared on the udder. Milking is carried out twice daily, at 6 a.m. and at 5 p.m. Each cow's yield is recorded by weighing.

Method of Milking.—It has been found that quietness is absolutely necessary, as all cows are extraordinarily sensitive to noise. It is well to speak to the cow before sitting down to milk. The forequarters should be milked first, and it is essential that every drop should be drawn from these quarters before starting on the hindquarters, which should be treated in like manner. Stripping is, in consequence, reduced to a minimum. Any interruption during milking should be avoided, as the yield may thereby be reduced. Quick milking is a necessity, and careful attention should be given to stripping, as the last drops of milk contain most butter-fat. At monthly intervals the fat percentage is determined by the Gerber test, and the butter-fat content of the milk of each cow is judged on the general average of these monthly tests.

Native Method of Milking in the Reserve.—In comparison with the approved method described above, the native custom is to milk once a day. The calf is allowed to suckle the cow for a few minutes in order to start the flow of milk and moisten the teats with its saliva. The milker then sits down to milk, the calf still standing by, and, should the cow refuse her milk, the calf is allowed to suck again, but is kept off by a herd-boy so long as the flow lasts. The remaining milk, which is very little, is then left for the calf. After milking, the calf is turned out with its dam until nightfall, when they are brought back to the *boma* and shut up separately. This method undoubtedly accounts for the unthrifty calves seen in the reserves. A cow which has proved to be a very poor yielder may not be milked at all, but is still maintained in the herd as an animal of value. This, of course, is because the number of cattle owned by a native is an indication of wealth, and the standing of the owner is very much in direct proportion to the live stock he owns.

This general system of native dairy husbandry does not tend towards udder

development, and consequently it is exceptional in native heifers or cows to find udder and teat development to any desirable extent. Through long ages of practice it may be that these characteristics have assumed genetical significance. This fact is supported by the observation that grade, even high grade, cows frequently show the same defects.

Milk Production (Whole Herd).—Table 1 records the total amount of milk produced by the herd during the period from September, 1933, to August, 1934. This period has been chosen as representative of the yield of an established herd of sixty-six native cows (34 Boran and 32 Masai) which has been built up under the conditions described. The figures in the column headed "Average yield per cow" have been calculated by dividing the total yield per month by the number of cows in milk during the month. Though this figure can, for a variety of reasons, be regarded only as an approximation, it may be taken as giving a reasonable measure of the milking capabilities of native cows kept under the conditions of management described. The yield figures have been graphed with rainfall records in Figure 1 and the correspondence in the curves will be readily seen. When the rainfall is excessive, as in the month of May, the upward tendency of the milk yield is continued for the two following months.

Milk Production of Individual Boran Cows (Foundation Stock).—Table 2 records the yields, in their various lactations, of seventeen of the individual Boran cows which made up the foundation stock. Of these seventeen animals, six gave no milk in their first lactation, but followed with considerable yields in subsequent lactations. This circumstance indicates the necessity of continuing animals through two lactations before a decision can be given as to the value of a native cow as a milk-producer. The table shows the continued high fat percentage in the milk of these animals.

TABLE 1

MILK PRODUCTION BY HERD OF SIXTY-SIX NATIVE COWS

SEPTEMBER, 1933–AUGUST, 1934

MONTH	No. of cows milking	Total yield	Average yield per cow
		Lb.	*Lb.*
1933			
September ..	30	4,727	157·7
October ..	29	4,269	147·2
November ..	28	5,595	200·0
December ..	28	6,453	230·5
1934			
January ..	30	5,816	193·9
February ..	31	4,567	147·3
March	45	8,054	179·0
April	53	9,049	170·7
May	46	10,206	221·9
June	45	10,305	229·1
July	49	11,629	237·3
August	46	10,198	221·7

TABLE 2

INDIVIDUAL MILK YIELDS OF SEVENTEEN ORIGINAL BORAN COWS MAKING UP FOUNDATION STOCK

Cow No.	Days in milk	Lactation	Total yield per lactation	Butterfat
			Lb.	*Per cent*
4	240	1st	2,720	6·0
	240	2nd	2,400	5·9
	246	3rd	2,580	6·0
	247	4th	2,400	5·8
5	Nil	1st	No milk	Nil
	242	2nd	2,130	5·5
	243	3rd	2,400	5·8
	155	4th	1,430	5·8
12	255	1st	1,970	5·0
	194	2nd	1,960	6·2
	—	3rd	—	—
	—	4th	—	—
22	Nil	1st	No milk	Nil
	247	2nd	2,420	6·1
	200	3rd	1,890	6·0
	—	4th	—	—
24	Nil	1st	No milk	Nil
	264	2nd	3,380	5·9
	238	3rd	2,140	6·2
	243	4th	3,300	6·0

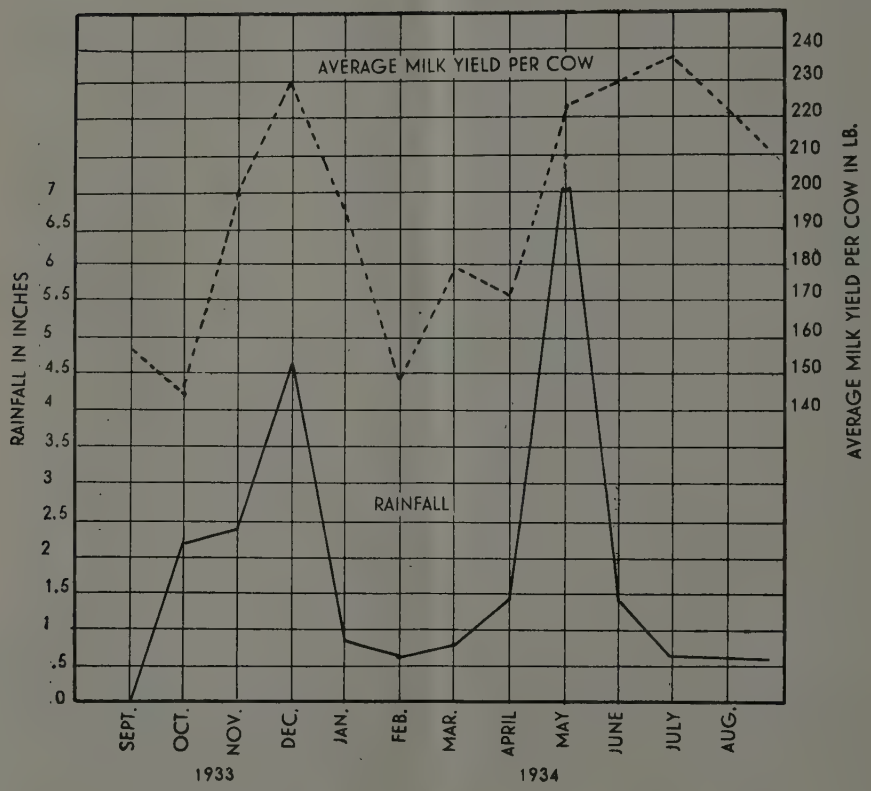

AVERAGE MILK YIELD PER COW
RAINFALL
RAINFALL IN INCHES
AVERAGE MILK YIELD PER COW IN LB.
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
.5
0
240
230
220
210
200
190
180
170
160
150
140
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
JULY
AUG.
1933
1934

FIGURE 1

TABLE 2—(*Contd.*)

Cow No.	Days in milk	Lactation	Total yield per lactation	Butterfat
			Lb.	*Per cent*
25	200	1st	2,170	5·0
	272	2nd	4,690	6·0
	244	3rd	2,480	5·9
	—	4th	—	—
30	192	1st	1,870	6·0
	278	2nd	2,600	6·0
	—	3rd	—	—
	—	4th	—	—
31	Nil	1st	No milk	Nil
	283	2nd	2,570	5·5
	215	3rd	2,700	5·8
	200	4th	1,930	5·9
44	Nil	1st	No milk	Nil
	228	2nd	1,800	5·7
	217	3rd	1,930	6·0
	206	4th	1,590	6·0
70	240	1st	2,570	5·9
	225	2nd	2,650	5·8
	212	3rd	2,350	6·2
	218	4th	2,100	6·1
80	215	1st	1,570	5·0
	236	2nd	2,100	5·2
	283	3rd	2,170	5·1
	—	4th	—	—
81	206	1st	1,430	6·0
	225	2nd	3,490	5·9
	205	3rd	3,420	6·2
	—	4th	—	—
82	200	1st	1,250	5·7
	200	2nd	1,690	6·0
	199	3rd	2,020	5·8
	178	4th	1,880	5·7
88	Nil	1st	No milk	Nil
	216	2nd	1,400	6·0
	143	3rd	1,970	6·2
	140	4th	1,340	6·4
94	225	1st	1,380	5·9
	191	2nd	1,010	5·8
	—	3rd	—	—
	—	4th	—	—
97	168	1st	1,490	6·0
	220	2nd	2,010	6·0
	208	3rd	2,460	5·9
	205	4th	2,200	6·6
98	199	1st	2,590	6·2
	210	2nd	2,530	6·0
	230	3rd	3,000	5·9
	200	4th	1,940	6·8

The detailed results given in Table 2 are summarized in the following table, which shows the average milk yield and butter-fat percentage in the first four lactations of the seventeen foundation stock Boran cows, for which data are available:—

Lactation	No. of cows in milk	Average No. of days in milk	Average milk yield per lactation	Average butter-fat
			Lb.	*Per cent*
1st ..	11	213	1,910	5·7
2nd ..	17	234	2,400	5·8
3rd ..	14	220	2,390	5·9
4th ..	10	199	2,010	6·1

This shows that on an average these foundation stock Boran cows are producing about 10 lb. or 1 gallon of milk per lactating day. Though this is not a high yield it is, so far as all existing data and observations go to show, more than double what a native cow produces under conditions in the reserves. Furthermore, it must be remembered that the cows to which these figures refer were in their fourth lactation, approaching their 8th or 9th year of age.

Milk Production of Boran Heifers Bred on Station.—Progeny bred on the Station from the original foundation stock have now reached the stage of milk production, and the milk yields of this, the second generation of Boran stock, are recorded in Table 3. Only in some cases has the whole of the first lactation of these animals been completed. Nevertheless, the figures are given to show that a substantial yield of milk may be got from young animals (from 30-38 months old) bred from properly handled native stock. One important point to note is that the progeny of native cows bred in the reserve would never reach the stage of milk production at such an early age. No conclusions can be drawn, however, until at least the end of the second lactation of these animals.

Milk Production of Individual Masai Heifers (Foundation Stock).—The Masai

TABLE 3
MILK PRODUCTION OF BORAN HEIFERS BRED ON STATION FROM FOUNDATION STOCK

Cow No.	Ex Dam No.	Days in milk	Lactation	Total yield	Butterfat
				Lb.	*Per cent*
4B	4	221	1st	1,784	5·29
5B	5	226	,,	1,663	6·01
22B	22	61	,,*	630	5·0
25A	25	215	,,	1,085	6·69
30A	30	230	,,	1,654	5·12
31A	31	251	,,	1,543	6·00
31B	31	229	,,	1,536	6·00
34A	34	207	,,	1,073	6·40
44A	44	223	,,	1,216	5·75
44B	44	225	,,	1,192	5·80
80A	80	212	,,	1,674	5·00
82A	82	259	,,	2,023	5·60
82B	82	236	,,	1,614	6·13
88A	88	196	,,	1,203	6·20
94A	94	237	,,	1,576	6·33
97A	97	211	,,	1,135	6·50
98A	98	221	,,	1,534	5·30
99B	99	205	,,	1,422	5·10
31C	31	Not completed			
12A	12	Not completed			
80C	80	Not completed			

*Not completed

TABLE 4
INDIVIDUAL MILK YIELDS OF 24 ORIGINAL MASAI HEIFERS MAKING UP FOUNDATION STOCK

Cow No.	Days in milk	Lactation	Total yield per lactation	Butterfat
			Lb.	*Per cent*
9	221	1st	1,430	6·6
7	228	,,	1,870	6·4
11	230	,,	1,910	5·9
13	187	,,	1,360	5·5
21	190	,,	1,040	5·8
28	167	,,	1,020	6·0
84	249	,,	1,620	5·8
117	170	,,	970	5·6
135	247	,,	2,080	5·3
136	222	,,	1,450	5·3
173	212	,,	900	6·2
197	236	,,	1,570	5·5
174	241	,,	940	7·0
175	224	,,	1,410	6·2
177	158	,,	1,700	5·5
178	229	,,	1,280	5·0
179	230	,,	1,280	6·0
180	154	,,	750	6·6
182	189	,,	950	6·0
184	206	,,	1,250	5·6
185	231	,,	1,290	5·6
189	237	,,	1,100	6·6
191	243	,,	1,480	5·6
192	150	,,	730	6·6

heifers which make up the foundation stock were procured at a much later date than the Boran stock and have consequently completed only one lactation. No progeny have as yet been reared from the Masai animals. In Table 4 are recorded the first lactation yields of the Masai heifers.

Production of Calves.—Records are kept of the weights of all calves born at the Station. The average birth weight for Boran and Masai calves is respectively 40 and 35 lb. It is considered of interest to set down here the feeding plan arranged for calves:—

1st day	Colostrum, 1 lb.
2nd day	Milk, 1 lb. morning and 1 lb. evening.
3rd to 7th days	Milk, 1½ lb. morning and 1½ lb. evening.
2nd week	Milk, 2 lb. morning and 2 lb. evening.
3rd week	Milk, 3 lb. morning and 3 lb. evening.

When the calves reach a maximum of 6 lb. of whole milk daily, separated milk is gradually introduced until it completely replaces the whole milk, after which separated milk is continued at the rate of 10 lb. per day until the calf is 5½ months old. Concentrates are allowed *ad lib.* from the age of six weeks until one month after the milk ration is discontinued. The concentrate mixture consists of simsim cake 2 parts, maize meal 2 parts, bran 1 part.

Unfortunately complete records of the live weight gains made by the stock bred on the Station have not been kept. However, in order to demonstrate the degree of development which takes place among stock under conditions of management obtaining at the Ngong Station, a group of comparative photographs with explanatory notes has been appended at the end of this article.

Production of Milk Products.—After the calves are fed, the surplus milk is separated and the cream is used for

BORAN COW NO. 25
Yield in 2nd Lactation, 4,690 lb. in 272 days
Average Butter-fat 6%

BULL OUT OF DAM NO. 25
Age—18 Months
Weight—517 lb.

BORAN COW NO. 81
Yield in 2nd Lactation, 3,494 lb. in 225 days
Average Butter-fat 5·9%

BULL OUT OF DAM NO. 81
Age—4 Years and 5 Months
Weight—1,102 lb.

BORAN COW NO. 97
Yield in 2nd Lactation, 2,010 lb. in 220 days
Average Butter-fat 6%

BULL OUT OF DAM NO. 97
Age—3 Years and 7 Months
Weight—1,011 lb.

butter-making. The butter is washed twice, weighed and converted into ghee (clarified butter). To produce one pound of ghee it has been found that approximately two gallons of milk are required.

have a much faster rate of growth and attain a much greater body weight. Selected bull calves have been reared which at 16 and 20 months of age weighed 627 and 756 lb.

TABLE 5

DATA RECORDING DISPOSAL OF SURPLUS MILK FOR MANUFACTURE OF BUTTER AND GHEE

DATE	No. of cows milking	Total milk yield	Births	Calves fed	Milk to calves	Milk to separator	Cream	Butter	Ghee	Butter-fat	Rainfall
		Lb.			*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Per cent*	*Inches*
1933											
September	30	4,727	3	16	2,917	1,810	159	109	85	5·6	Nil
October ..	29	4,269	6	18	3,219	1,050	104	64	49	5·6	2·19
November	28	5,595	4	16	2,955	2,640	271	171	125	5·6	2·29
December .	28	6,453	4	16	2,873	3,580	316	200	167	5·8	4·60
1934											
January ..	30	5,816	3	12	2,163	3,653	362	242	170	5·6	0·79
February .	31	4,567	7	12	2,002	2,564	222	149	106	5·0	0·55
March ..	45	8,054	20	23	4,231	3,823	346	228	159	5·0	0·77
April ..	53	9,049	8	26	4,627	4,421	421	298	196	5·3	1·43
May ..	46	10,206	2	20	3,645	6,560	657	527	354	6·5	6·73
June ..	45	10,305	3	16	2,927	7,378	765	595	381	6·2	1·46
July ..	49	11,629	8	12	2,391	9,238	862	665	429	5·5	0·53
August ..	46	10,198	1	12	1,783	8,415	850	631	429	6·0	0·59

Total Herd 66. Ratio of Milk to Ghee 2·07 gallons : 1 lb. Ghee.

Table 5 records the amount of milk separated and the amount of butter and ghee made therefrom during the year from September, 1933, to August, 1934.

Summary and Conclusions. — The preliminary results here recorded demonstrate that unselected native cattle, bought at random in the reserves, show great promise as producers of milk and dairy products if kept under controlled and regular conditions of management. Under such conditions the milk yield is more than double that of a native cow under native methods of husbandry. Furthermore, the managed animals become productive at a much earlier age.

Though specific weight data are not fully available, observation clearly reveals that animals bred from native foundation stock and kept under good management

Although the amount of milk produced is small compared with that produced by imported grade stock, this is compensated for by its very high butter-fat content. Whereas heavy milking breeds usually average a little over 3 per cent butter-fat, milk from the native cow gives an average of 5.7 per cent. The average yield of butter-fat per cow over all dairy farms in Kenya for 1932 is given as 32 lb. At the Ngong Station the average yield for the year 1933-34 was 42 lb. per cow.

It is important to bear in mind that the improved production has been obtained solely by the use of natural grazing. Very much higher yields could doubtless be achieved were supplementary feeding with concentrates introduced.

Review

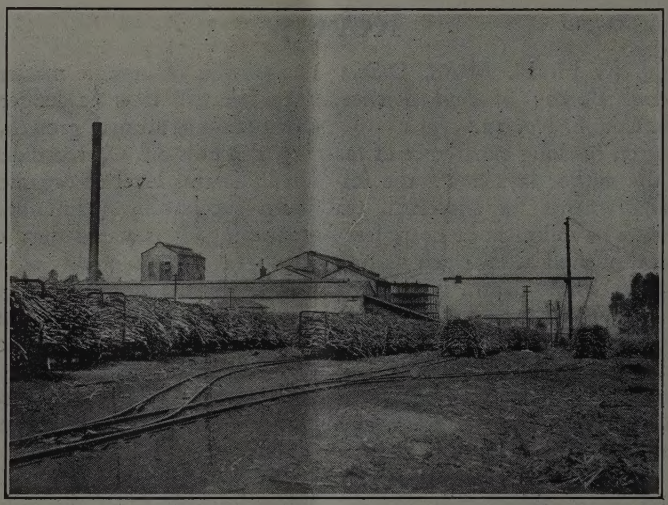
TEA SOILS, *by* H. H. Mann, D.Sc.: *Imperial Bureau of Soil Science, Tech. Comm. No.* 32.

Drawing on his long experience of tea in India, the author lays down the following requirements for successful tea cultivation: The soil must be deep, free-draining and of moderately open texture throughout its whole depth. It must be definitely acid, pH 5.2 to 5.6 being the most suitable degree of acidity, and "reactive" calcium, or at any rate free calcium carbonate, must be almost entirely absent. With these conditions satisfied, the tea bush appears to be able to make good growth on relatively leached and impoverished soils.

As to the quality of tea, it is important that the amount of organic matter and nitrogen be sufficient and within certain limits in relation to the reactive part of the soil. If these are present in too large amount, there is a tendency to rank growth and loss of quality; if the proportion of organic matter and nitrogen falls till it is no longer capable of maintaining normal growth, quality of tea also falls off. On the older tea estates in India this level of organic matter has been successfully maintained by green manuring. It is stated that, other things being favourable, quality of tea is affected largely by the amount of available phosphoric acid present. Response to phosphate manuring has been obtained on some soils in India. Large amounts of potash, either present in the soil or added as fertilizer, have very little effect on the quality of tea produced.

In the light of the above, the author gives an account of the soils of the tea regions of the world. From this it would appear that, in regard to tropical soils, as the author himself says on the relation of soil to quality of tea, the present position of our knowledge is almost the same as it was twenty years ago.

W.E.C.



The Uganda Sugar Factory Limited

SUGAR MANUFACTURERS AND
SPIRIT DISTILLERY OWNERS

Registered Office:

LUGAZI, Uganda

Telegrams:

"SUCCESS" Lugazi

Phone No. 43, Jinja *Codes* { Bentley's and Private

P.O. Box No. 1

LUGAZI

UGANDA